Overfill Protection for Storage Tanks in Petroleum Facilities

ANSI/API STANDARD 2350-2012
FOURTH EDITION, MAY 2012

AMERICAN PETROLEUM INSTITUTE

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Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

Contents

Introduction

This standard addresses overfill protection for petroleum storage tanks. It recognizes that prevention provides the most basic level of protection, thus while using both terms “protection” and “prevention”, the document emphasizes prevention. The standard's scope covers minimum overfill (and damage) prevention practices for aboveground storage tanks in petroleum facilities, including refineries, marketing terminals, bulk plants, and pipeline terminals that receive flammable and combustible liquids. It cannot cover every case and unique situation.

API Publication 2350, *Overfill Protection for Storage Tanks in Petroleum Facilities* was first issued in 1987. The second edition was rewritten and expanded with emergency spill prevention programs in mind. The third edition built on the second edition with the scope expanded to include Class I and Class II hydrocarbon liquids as well as tankage in broader usage. References to PEI 600 addressed potential overfills for receipts of petroleum products from wheeled vehicles.

The fourth edition continues to build on experience and new technology through the use of management systems. Since operations are the primary overfill prevention safeguard, new definitions and requirements are established for alarms. Risk reduction is also addressed by current practices and generally accepted industry practice.

During the development of the current and prior editions of this document, careful consideration was given to the benefits provided by overfill protection for tanks in petroleum facilities relative to:

— safety and environmental protection,

— optimization of the work place and operating practices,

— inspection, testing, and maintenance,

— equipment and system selection and installation,

— safe work practices, emergency procedures and training,

— management of change programs relative to tank overfill prevention,

— inclusion of current technology and practices related to process control and automated safety instrumented systems.

All of the sections and annexes in the document were revised with the 4th edition.

Illustrations are provided to help explain the tank capacity and level definitions. API Standard 2350 covers overfill protection only. Overfill protection includes concern for product overflow and tank damage. This standard does not address other issues related to aboveground storage tanks such as minimum operating levels.

The essential elements of this document are based on current industry safe operating practices and existing consensus standards. Federal, state, and local regulations or laws may contain additional requirements for tank overfill protection programs. For existing facilities the results of a risk-based analysis of aboveground atmospheric petroleum storage tanks may indicate the need for more protection against overfilling. In such cases some provisions from this standard may be suitable.

Overfill Protection for Storage Tanks in Petroleum Facilities

1 Scope and Purpose

1.1 Scope

The scope of this standard is intended for storage tanks associated with marketing, refining, pipeline and terminals containing Class I or Class II petroleum liquids. Use is recommended for Class III petroleum liquids. This standard does not apply to:

— underground storage tanks;

— aboveground tanks of 1320 US gallons (5000 liters) or less;

— aboveground tanks which comply with PEI 600;

— pressure vessels;

— tanks containing non-petroleum liquids;

— tanks storing LPG and LNG;

— tanks at service stations;

— tanks filled exclusively from wheeled vehicles (i.e. tank trucks or railroad tank cars); and

— tanks covered by OSHA 29 *CFR* 1910.119 and EPA 40 *CFR* 68 or similar regulations.

This standard recommends application of PEI Recommended Practice 600 Recommended Practices for *Overfill Prevention for Shop-Fabricated Aboveground Tanks* for overfill protection where applicable for aboveground tanks falling outside the scope of this document.

1.2 Purpose

The purpose of this standard is to assist owner/operators and operating personnel in the prevention of tank overfills by implementation of a comprehensive overfill prevention process (OPP). The goal is to receive product into the intended storage tank without overfill or loss of containment.

1.3 Minimum Requirements

This standard is one of minimum requirements. Alternate approaches or variations on the principles of this standard that provide equivalent or more robust overfill prevention are acceptable. Alternate approaches may be needed when the tank system varies from the typical configurations described in this standard. The rationale for the implementation of each overfill prevention process (OPP) should be documented and retained by the owner and operator.

2 Normative References

There are no references designated as normative for this document.

References included in various locations in the document and in the Bibliography are provided for information only and are not normative parts of this standard.

3 Terms and Definitions

For the purposes of this document, the following definitions apply:

NOTE Users of prior editions of API 2350 should note that several definitions and terms that have changed are important to the implementation and use of this standard.

3.1
alarm
Alarms require action. They are audible and visible means of indicating to operating personnel an abnormal condition requiring a specific response (high tank level, equipment malfunction or process deviation) (see 5.1.2).

3.1.1
diagnostic alarm
An indication that there has been a malfunction of equipment. It applies to any condition affecting the proper operation of instrumentation, control or alarm systems (including power outages) that requires operating personnel response. This is sometimes called a "trouble alarm" (see 5.1.2.2).

3.2
alert
Alerts are audible and visible notification indicating an equipment or process condition that requires awareness.

NOTE 1 For this standard, alerts do not require specific action (see 5.1.3).

NOTE 2 At their discretion, companies may choose to establish required action as a response to an alert.

3.3
AOPS level
The tank level at which the AOPS system is activated (see 4.4.2.4).

3.4
attendance
The term describing when personnel are physically on site at the facility where the tanks are located during receiving operations.

3.4.1
fully-attended (locally monitored) facility
Assigned personnel are on the premises continuously during the entire receipt of products from pipelines or marine vessels. Personnel on site either have the ability to terminate the receipt for the tank of concern or are in constant contact with people who have the ability to terminate the receipt for the tank of concern.

3.4.2
semi-attended (locally and remotely monitored) facility
Assigned personnel are on the premises (at a minimum) during the initial and final portions of the receipt of products from pipelines.

3.4.3
unattended (remotely monitored) facility
A facility not requiring assigned personnel to be on the premises during any part of a receipt of products from pipelines. Personnel at local or remote control centers monitor the receipts using "real time" data with the ability to terminate the receipt for the tank of concern.

3.5
authority having jurisdiction
A regulatory agency, owner/operator managment at local or corporate level, or individuals responsible for enforcing the requirements of a code or standard, or for approving equipment, materials or procedures.

3.6
automated overfill prevention system (AOPS)
An overfill prevention system not requiring the intervention of operating personnel to function (see 5.1.1 and Annex A).

3.7
automatic tank gauge (ATG)
A measuring device; a mechanical or electronic sensor designed to continuously measure and transmit the liquid level in a storage tank without personnel action (see Annex C.3).

3.8
automatic tank gauging system (ATGS)
A system incorporating an ATG; the system is designed to continuously measure liquid level in a storage tank. No operating personnel action is required to determine the level. The measured values, alerts and alarms are transmitted to a local and remote monitoring and control center that can display the levels and receive alerts and alarms. An ATG system may also have a local display at the tank.

3.9
capacity
The volume (amount) of product contained in a tank at designated levels (i.e. the levels of concern (LOCs)).

3.9.1
critical capacity
The capacity at critical high level. Also the “design capacity” as specified in API 650 (see 4.4.2.1).

NOTE Special note to users of prior editions of API 2350: the term “safe fill height” is no longer used.

3.9.2
nominal shell capacity
The volume of a vertical, cylindrical tank up to top of the cylindrical section (also called nominal capacity).

3.10
competent person
An individual who is capable and able to perform the assigned duties as determined by management in a specific area of operations.

3.11
continuous level sensor
A measuring device; a mechanical or electronic continuous level sensor designed to continuously measure the liquid level in a storage tank without personnel action (see Annex C.2).

3.12
control center
An operations center with the ability to monitor and control operations as at the subject facility.

NOTE Can be local (at the subject facility) or remote (not at the subject facility).

3.13
critical high level
CH
The highest level in the tank that product can reach without detrimental impacts (i.e. product overflow or tank damage) (see 4.4.2.1).

NOTE In prior editions of API 2350, this was called "overfill level" or maximum capacity.

3.14
Department of Transportation
DOT
A United States (U.S.) regulatory agency. The U.S. Department of Transportation (DOT), Pipeline and Hazardous Materials Safety Administration (PHMSA), Office of Pipeline Safety (OPS) develops and enforces regulations for the U.S. pipeline transportation system.

3.15
facility
A location with tanks within the scope of this standard which receives Class I or Class II liquid hydrocarbons.

3.16
facility operator
See owner/operator.

3.17
final element
Valves, pumps or other equipment that stops or diverts flow to a tank to prevent tank overfilling.

3.18
flammable and combustible liquids
NFPA 30-2008 defines the following classes of liquids:

3.18.1
Class I liquid
A flammable liquid with a closed cup flash point below 100 °F (37.8 °C) and a reid vapor pressure not exceeding 40 pounds per square inch absolute (2068 millimeters of mercury) at 100 °F (37.8 °C).

3.18.2
Class II liquid
A combustible liquid with a closed cup flash point at or above 100 °F (37.8 °C) and below 140 °F (60 °C).

3.18.3
Class III liquid
Liquid with flash points above 140 °F (60 °C).

3.19
gap analysis
An analysis to determine if results of a risk-based analysis meet the acceptable levels as determined by the owner and operator (4.3).

3.20
gauge level equivalent
A physical measurement converted to a product level gauge reading at the same point in the tank.

3.21
hazard
A condition or inherent physical or chemical characteristic (flammability, toxicity, corrosively, stored chemical, electrical, hydraulic, pressurized or mechanical energy) that has the potential for causing harm or damage to people, property or the environment.

3.22
high-high tank alarm
LAHH
An alarm generated when the product level reaches the high-high tank level.

3.23
high-high tank level
HH
An emergency action alarm level set sufficiently below the critical high level to enable termination of a receipt before the critical high level is reached (see 4.4.2.2).

NOTE In prior editions of API 2350, this was called "safe fill height" or "tank rated capacity".

3.24
incident
An occurrence with undesirable consequences affecting safety, health, the environment or facility economics.

3.25
independent alarm
An alarm function separate from the device or system used for routine operational tank level measurement.

3.26
independent sensor
A sensor that is not used in the ATG system.

3.27
levels of concern
LOCs
Calculated product levels in a tank that allow the owner and operator to determine appropriate levels to set alerts, alarms or AOPS functions (see 4.4.2, Figure 1, and Figure 2).

3.28
local
Indicates located or operated on-site at a facility.

3.29
manual overfill prevention system
MOPS
A system requiring operating personnel action to function (see overfill prevention system and 5.1).

3.30
marine vessel
A barge or tanker ship that can deliver product directly into petroleum facility tanks (usually through temporary connections to facility pipelines).

3.31
maximum working level
An operational level that is the highest product level to which the tank may routinely be filled during normal operations (see 4.4.2.3).

NOTE In prior editions of API 2350, this was called “normal fill height”.

3.32
near miss
A condition with potential for undesirable consequence.

3.33
notification
See alert.

3.34
operating personnel
The people who “do the work” of managing tank receipt or dispatch operations; whether located at a facility, local or remote control center, operating personnel are available, have access to equipment and controls, and are competent to respond to notifications, alerts, alarms, and abnormal conditions pertaining to receipt operations at a facility.

3.35
overfill prevention process
OPP
A management system consisting of multiple components to assure that safeguards to tank overfill are in place and sustainable (see Section 4).

3.36
overfill prevention system
OPS
The components within the OPP that addresses the equipment and personnel requirements.

3.37
owner/operator
The facility owner, manager, supervisor, or other assigned person(s) responsible for receiving product from a transporter.

3.38
parallel tanks
Two or more tanks at the same facility that can be filled simultaneously and effectively operated as one tank (see precautionary advice in 4.4.2.2.3).

3.39
person in charge
A U.S. Coast Guard regulatory term from 33 *CFR* 154.700 for a trained and experienced individual designated as a “person in charge” of transfer operations at marine terminals.

3.40
personnel
See operating personnel.

3.41
Piping

3.41.1
facility piping
Local product piping located within a specific facility.

3.41.2
mainline pipeline
A pipeline that transports petroleum products between facilities and does not include piping used to transfer products within facilities. Piping used locally to unload barges typically is not considered a “mainline pipeline”.

3.41.3
marine receipt piping
Piping used to transfer product from a marine vessel into land based storage tanks. Typically most marine receipt piping is facility piping.

3.42
programmable logic controller
PLC
Used to monitor and control a process (i.e. transferring product to and from tanks).

3.43
product
Class I or Class II petroleum liquid as defined by NFPA 30.

3.44
proof testing
A complete OPS instrumentation loop test through the primary sensing element verifying appropriate response all the way from sensors to the final control element including alarms (see 4.5.5.4).

3.45
receipt
A delivery or transfer of product into a tank.

3.46
remote
Indicates away from a particular facility with tankage (i.e. not local).

3.47
residual risk
The risk that remains after application of overfill prevention safeguards.

3.48
response time
The period of time required to terminate a receipt (see 4.4.2.5).

3.49
risk
The probability and consequences of exposure to a hazard, hazardous environment or situation that can result in harm.

3.50
risk assessment
The identification and analysis with judgments of probability and consequences (either qualitative or quantitative) of the likelihood and outcome of specific events or scenarios that result in harm or damage.

3.51
risk-based analysis
A review of potential hazards and needs to eliminate or control such hazards based on a formalized risk assessment.

3.52
safe fill level
See high-high tank level.

3.53
supervisory control and data acquisition system
SCADA
A computer-based system or systems used by a controller in a control room that collects and displays information about a facility and may have the ability to send commands back to a remote facility.

3.54
sensors
Continuous or point type product level sensing devices used to trigger alarms, alerts, and shutdown and diversion actions.

3.55
tank
An aboveground vertical, cylindrical receiving vessel for petroleum storage.

3.56
terminal
An owner and operator, proprietary or third-party facility with tanks that receive, ship, dispense or transfer product.

3.57
terminate
Stopping flow of product into a tank (see 4.1.3).

3.58
transfer operations
For product receipt, this includes all associated activities including notification (either verbal, electronic or by other means) of a potential tank overfill and termination of flow into the tank (shutdown or diversion of product) to prevent a potential tank overfill.

3.59
transporter
The mainline pipeline or marine vessel person(s) responsible for product transfer, and who have the ability to terminate the receipt.

3.60
watchdog timer
WDT
A diagnostic device that performs a specific operation after a certain period of time if something goes wrong with an electronic system and the system does not recover on its own.

4 Overfill Prevention Process (OPP)

4.1 OPP Overview

4.1.1 Prevention of tank overfills is best achieved by:

a) awareness of available tank capacity and inventory;

b) careful monitoring and control of product movement.;

c) use of reliable instrumentation, sensors and systems; and

d) use of automatic overfill prevention systems (AOPS) where deemed appropriate by a risk assessment and risk-based analysis.

4.1.2 Monitoring of available tank capacity is accomplished either manually or by use of a continuous level sensor or an automatic tank gauging system. Monitoring, together with established orderly termination procedures (emergency shutdown and product diversion), provides for overfill protection. Aboveground storage tank high-high level sensors with alarm and signal systems constitute an additional means of protection against tank overfills. Automated shutdown or diversion systems can provide further protection.

NOTE Manual monitoring may be done from the top of the tank prior to product receipt, but only from ground level during receipt and for at least 30 minutes afterwards.

4.1.3 The OPP is simple in concept. When receiving product into a tank, the flow is terminated prior to the tank level reaching the critical high (CH) level. Use of the word “terminate” in this standard means any of the following:

a) terminating the source of pressure (e.g. shutting down a pump);

b) diverting the incoming flow;

c) shutting down the flow (closing a receipt valve); or

d) using an alternative method for bringing the receipt process to a safe state without overfilling the tank.

While this desired end-result termination seems simple, experience suggests the need for a systematic OPP to ensure success over time.

4.1.4 Tank overfilling consequences and risk vary from one facility to another. Consequently, a comprehensive and flexible approach is provided. This allows the owner and operator of each facility to assess and implement the appropriate site-specific level of overfill protection needed. The OPP in this standard is flexible and may be used to address either existing or new tank receipt operations as well as existing or new safeguards to prevent overfill. If a gap analysis shows the risk with existing safeguards does not meet established criteria, then further risk reduction is required.

4.1.5 The OPP consists of several fundamental components:

a) management system (4.2 and Annex B);

b) risk assessment system (4.3 and Annex E);

c) defining operational parameters (4.4);

d) requirements for procedures (including those for receipt termination) (4.5); and

e) equipment systems (Section 5 and Figure 1, Figure 2, Figure 3).

4.2 Requirements for the Management System

A management system is required for conformance with API 2350, but this standard does not specify how to implement such a system. This task is the responsibility of the owner and operator. A properly structured management system provides the controls on all components of OPP so that each component is coordinated with other components and is assessed, managed and kept current as people and equipment change.

A management system is the framework of administrative processes and procedures used to enable the owner and operator to fulfill the tasks required to reduce overfills to an acceptable level. This system is often built around the familiar Plan-Do-Check-Act cycle described in Annex B.

The management system for OPP shall include (as a minimum) the following elements:

a) formal documented operating procedures and practices, including safety procedures and emergency response procedures;

b) competent operating personnel;

c) functional equipment systems, tested and maintained by competent personnel;

d) scheduled inspection and maintenance programs for overfill instrumentation and equipment;

e) systems to address both normal and abnormal operating conditions;

f) a management of change (MOC) process that includes personnel and equipment changes;

g) a system to identify, investigate, and communicate overfill near misses and incidents;

h) a system to share lessons learned;

i) a follow-up system to address any needed mitigation of circumstances leading to near misses or incidents; and

j) communication systems protocols within the owner and operator organization and between the transporter and the owner and operator that are designed to function under abnormal as well as normal conditions.

The management system shall be documented (see 4.5, Procedures).

4.3 Requirements for Risk Assessment

A risk assessment shall be used by the owner and operator to categorize risks associated with potential tank overfills as either meeting or not meeting the criteria of the stakeholders (owner and operator, employees, regulatory authorities, transporter, public). This standard does not specify how risk assessments should be conducted (e.g. qualitative or quantitative, simple or complex). Since risks are site specific, as well as specific to the values of the stakeholders, no rules for determining acceptable risk are provided by this standard. Annex E is a conceptual overview showing some of the elements of a risk assessment process. A variety of references on risk evaluation and approaches to risk reduction are provided in the Bibliography.

Risk assessment is the responsibility of the owner and operator. Persons who are familiar with tank facilities and operations as well as risk assessment shall participate in these analyses. The owner and operator shall include information from the transporter (i.e. pipeline or marine) to enable consideration of potential off-site emergency response impact as well as risk assessment on the receiving system. Secondary consequences resulting from the operation of AOPS shall be considered during the OPP risk assessment (see 5.5). Where possible, the transporter, owner and operator should jointly conduct risk assessments on the possible overfill scenarios and response. Risk analyses shall consider (but not be limited by) regulatory requirements.

If the stakeholders find that the risks do not meet the gap assessment criteria, then risk reduction is required. This may be accomplished by a change of operating characteristic (i.e. receipt flow rates), by a change of operating procedures and practices (i.e. attendance), a change of equipment systems and alarms, additional automation of systems through the transporter or the installation of an AOPS.

NOTE It should be recognized that all aboveground storage tanks and particularly those in excess of 150 ft in diameter that contain Class I or Class II liquids have the potential for a significant emergency condition should an overfill occur. These concerns are discussed in API 2021, *Management of Atmospheric Storage Tank Fires*.

4.4 Defining Operating Parameters

4.4.1 General

In order to initialize an OPP, the owner and operator shall establish levels of concern (LOCs) and tank operating categories for every tank included in the OPP.

4.4.2 Establish Levels of Concern (LOCs)

The owner and operator shall establish LOCs for all tanks covered by this standard. Tank LOCs are established by facility operators and owners based on:

— product(s) to be stored in the tank;

— the field experience and operating practices for each facility and each specific tank;

— the operating parameters for valves and manifolds;

— the tank capacities and physical conditions;

— the amount of product to be delivered, received, transferred; and

— the rate of product flow into each tank.

Establishing LOCs should take into account the OPS category of the tank as illustrated in Figure 3 in 4.4.5. In addition, the tank strapping table (whether hard copy or electronic) shall be accurate (API *MPMS* Ch. 2, *Tank Calibration*).

As a minimum, three LOCs shall be established for each tank (see Figure 1):

— critical high level (CH),

— high-high level (HH), and

— maximum working level (MW).

A fourth level (the AOPS Level) shall be established if an AOPS is used with an actuation level that is different from high-high level (see Figure 2).

Once LOCs are established for a tank, they can be used to set alarm or alerts (see 5.1.2 and 5.1.3.)

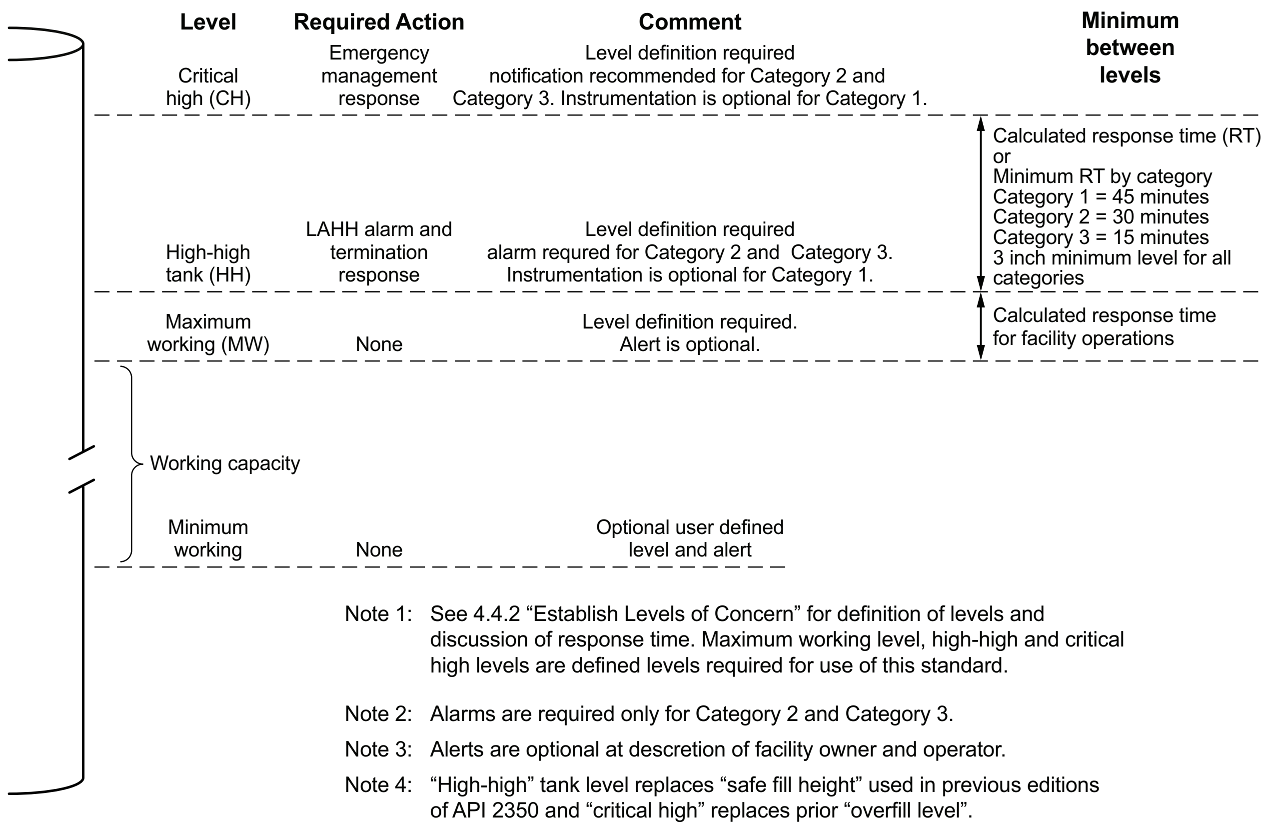


Figure 1—Minimum Tank Levels of Concern (LOCs)

LOCs should be displayed near the manual gauge hatches and at tank gauging equipment, and be available at remote monitoring stations so they are visible to personnel monitoring the tank levels.

Tanks used as pipeline relief tanks shall maintain the proper amount of free volume in the tank based on the anticipated relief event. This required volume should be adjusted for in the tank level between HH and CH, MW and HH or in some other way as defined by the owner and operator.

4.4.2.1 Critical High Level

Determining LOCs begins with establishing the critical high level. The critical high level establishes the point from which the high-high tank LOC is determined (e.g. see Annex D).

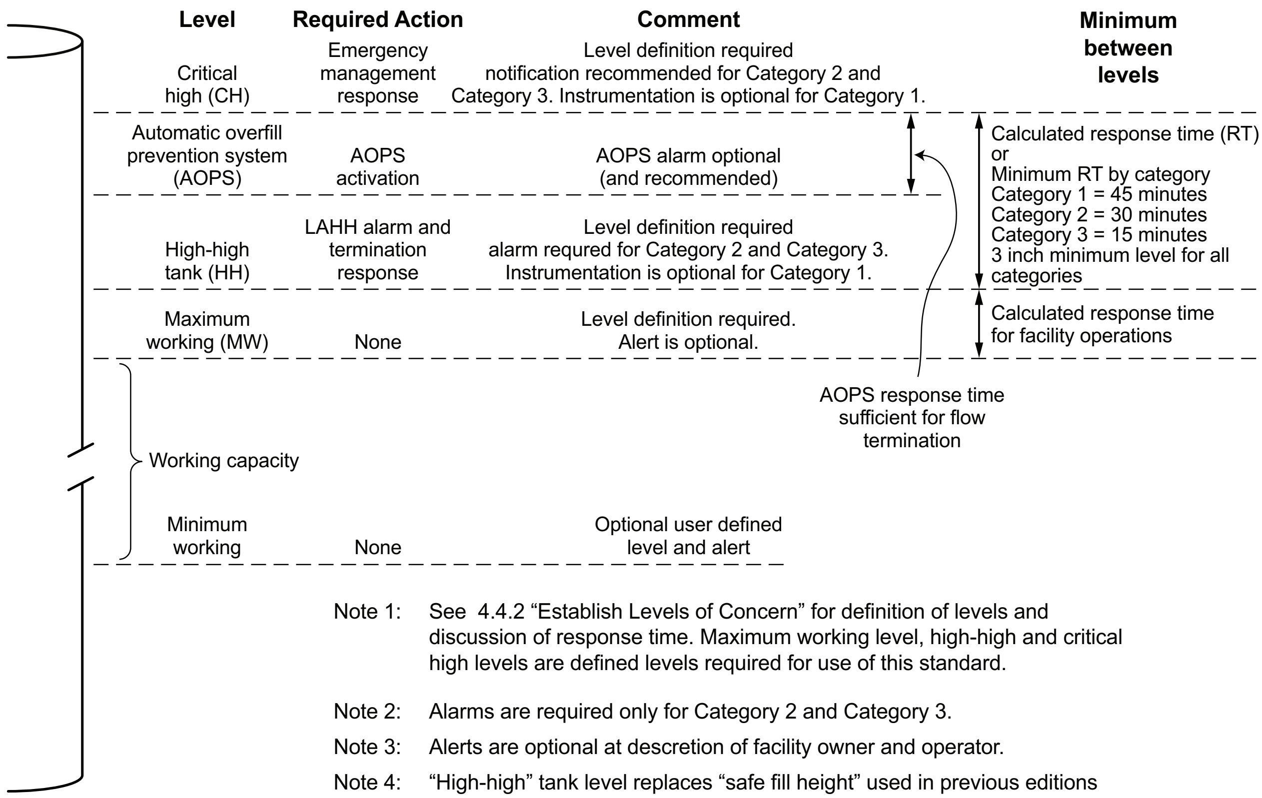
The critical high level is based on the physical characteristics of a tank and is the highest level in the tank that product can reach without (or which initiates) detrimental impacts (i.e. product overflow or tank damage). It is the lowest gauge level equivalent of any of the following:

— overflow of product—the maximum fill level of product within a tank as measured from the gauging reference point (e.g. a striker plate) above which any additional product shall overfill and spill out of the tank;

— damage from mechanical contact of: the floating roof, floating roof seals, floating roof legs, foam dams or other appurtenances with the tank structure;

— where allowable tank stresses shall be exceeded; or

— an owner and operator designated critical high level lower than those described above.



Note 1: See 4.4.2 "Establish Levels of Concern" for definition of levels and discussion of response time. Maximum working level, high-high and critical high levels are defined levels required for use of this standard.

Note 2: Alarms are required only for Category 2 and Category 3.

Note 3: Alerts are optional at descretion of facility owner and operator.

Note 4: "High-high" tank level replaces "safe fill height" used in previous editions of API 2350 and "critical high" replaces prior "overfill level".

Note 5: An optional automatic overfill protection system (AOPS) activation point is shown to illustrate that if implemented its location should be above high-high and below critical high with indicated response times.

Figure 2—Tank Levels of Concern (LOCs) with Optional AOPS

Examples of when the owner and operator may choose to set the critical high level lower than specified in the listing above include:

— when maximum levels are reduced temporarily or permanently;

— when a shell repair is made; and

— where seals rise above the vents or top lip of a tank (causing excessive vapor emissions possible air pollution violations).

4.4.2.2 High-High Tank Level

4.4.2.2.1 The high-high tank level is an emergency action alarm level set sufficiently below the critical high level to enable termination of product receipt before the critical high level is reached. The vertical distance in the tank between the critical high level and the high-high tank level is calculated based on the response times required to terminate a receipt at the maximum flow rate specific to the tank under consideration.

4.4.2.2.2 The response time used in these calculations should be determined taking into account factors discussed in 4.4.2.5. Once this response time-volume (response time × flow rate) is calculated, an accurate and up-to-date tank strapping table (hard copy or electronic) shall be used to determine the vertical distance in the tank corresponding to that time-volume.

NOTE The maximum flow rate shall take into account all lines that can flow simultaneously into the tank.

At a minimum, the distance between the critical high level and the high-high tank level shall not be less than 3 inches to account for potential errors in data and measurements.

4.4.2.2.3 Special consideration should be given to certain types of installations (i.e. tanks operated in parallel) to make sure the high-high tank level alarms meet the expectations of the system as it is operated (e.g. if tanks being operated in parallel are of different height or elevation, then one tank may be "full" (reach its overfill level) before the other(s)).

4.4.2.2.4 Product levels reaching the high-high tank level should be lowered as soon as practical to the maximum working level.

4.4.2.3 Maximum Working Level

The maximum working level is an operational level and is the highest product level to which the tank may routinely be filled during normal operations. No alarm is required at this level, but alerts may be established by the owner and operator to aid operations. The maximum working level is set at a distance below the high-high alarm level on the tank based either on response time or facility operations.

The maximum working level should be set at a point low enough so that when filled to that level the high-high tank level alarm cannot be inadvertently activated as a result of:

— product level increase due to thermal expansion;

— wave action caused by turbulence, wind; and

— wave slosh height in geographic areas where seismic activity may be of concern.

4.4.2.4 AOPS Level

The AOPS level is an emergency action level set sufficiently below the critical high level to enable automatic termination of a receipt before the critical high level is reached.

The vertical distance in the tank between the critical high level and the AOPS level is calculated based on the response time required by the automated system to terminate a receipt at the maximum flow rate specific to the tank under consideration. At a minimum, the distance between the critical high level and the AOPS level shall not be less than 3 inches to account for potential errors in data and measurements.

The AOPS level should be set at or above the high-high tank level. However, it may be preferable to have the AOPS set above the high-high tank level in order to give manual overfill prevention system (MOPS) operating personnel time to terminate the receipt prior to the AOPS activation.

4.4.2.5 Response Time (RT)

Response time is the period of time required to complete a set of responses to a given alarm or alert in order to prevent triggering the next higher alarm and alert or possibly overfilling or damaging the tank (Figure 1 and Figure 2).

Response times shall be calculated. At a minimum, all of the following should be considered when determining the response time:

a) communication time between detection of the alarm or alert condition and the notification of operations personnel who can respond to the notification and stop or divert flow if necessary; this may include verification time in order to avoid inappropriate response to false alarms;

b) time for operations personnel to analyze the situation and make appropriate response;

c) system time required to initiate response actions (including a shut down or diversion of flow to the tank if warranted);

d) time required to complete response actions (up to termination of the receipt);

e) time required to verify that all system elements are responding appropriately and to take appropriate action if the system is not responding properly; and

f) safety factor applied (if applicable).

4.4.2.5.1 The high-high tank response time is the period of time required to terminate the receipt flow to a tank in response to reaching the high-high tank level in order not to reach the critical high level.

As an interim measure, if tank specific calculations of response time are not available, a minimum standard response time based on category can be used as shown in Table 1 and in Figure 1 and Figure 2.

To establish that the actual response times are not greater than the values given in Table 1, the owner and operator shall verify and document as soon as possible that the table values equal or exceed (allow more time) than the actual required high-high tank response. This can be done through operating experience, calculations or any other suitable method.

Calculated response times of a shorter duration than those shown in Table 1 are acceptable and may be used. Calculated response times less than 10 minutes shall be justified by a human factors analysis.

NOTE There are many definitions for “Human Factors Analysis”. For this purpose it means a deliberate determination (i.e. defined by De Greene, K. B. (1970) “Human factors [in the broad sense] includes training, manpower determinations, analysis, evaluation, equipment design” or Parker, S. P. (1989) “The study of human capability and psychology in relation to the working environment and the equipment operated by the worker”.

Table 1—Minimum High-High (HH) Response Time

Minimum High-High Tank (HH) Level Response Time (if not calculated)	
Category	**Time in Minutes**
1	45
2	30
3	15

4.4.2.5.2 AOPS response time is the time period required for the AOPS system to terminate the receipt before reaching critical high.

4.4.2.5.3 Alert response times are the period of time required to respond to an alert in order to prevent triggering the next higher alarm or alert.

4.4.2.5.4 Response time variation may exist among various alarms and alerts depending on the required actions associated with each alarm and alert.

4.4.3 LOC Documentation

Documentation shall be maintained that establishes the basis for the LOC settings defined in 4.4.2. This LOC documentation shall be updated whenever there is a change to the LOCs. Some facilities include these updated LOCs in strapping tables (hard copy or electronic) to aid personnel planning receipts.

4.4.4 Periodic LOC Reviews

4.4.4.1 General

Once established, the LOCs shall be reviewed periodically (five years as a maximum) as required by the facility's OPP to ensure that they remain set appropriately for current conditions. In addition triggers for review of LOC settings include those associated with MOC (i.e. changes to the tank) and changes to the operation of the tank or other aspects of the OPP.

4.4.4.2 Physical Changes Warranting LOC Review

Conditions that specifically warrant an LOC review and a tank calibration include significant physical changes to a tank or facility, such as:

- new tank;
- change in floating roof tank seals;
- installation of geodesic domes or other kinds of fixed roofs (e.g. when external floating roof tanks receive retrofit covers);
- new internal or external floating roof;
- side vent changes;
- shell extensions;
- new tank bottom;
- addition of ancillary equipment (i.e. foam chambers);
- recalibration or re-strapping of the tank;
- change of tank gauging equipment; and
- addition of a gauge tube with datum or change in datum and strike plate.

4.4.4.3 Operational Changes Warranting LOC Review

An LOC review shall be conducted when there are operational changes from the most recent determination, such as:

- change in product;
- change in incoming or outgoing lines;
- change in maximum flow rates;
- change in service if it impacts structural integrity (corrosion, temporary repairs);
- change in operations (i.e. parallel tank, floating or high suction, continuous mixer operation); and
- change in response time resulting from staffing, operation or equipment changes.

After review, the affected LOCs should be documented and implemented.

4.4.5 Establishing Tank Categories

4.4.5.1 General

Operators shall categorize each tank under consideration for overfill prevention. Figure 3 provides illustrations of the three categories that are described in the following sections.

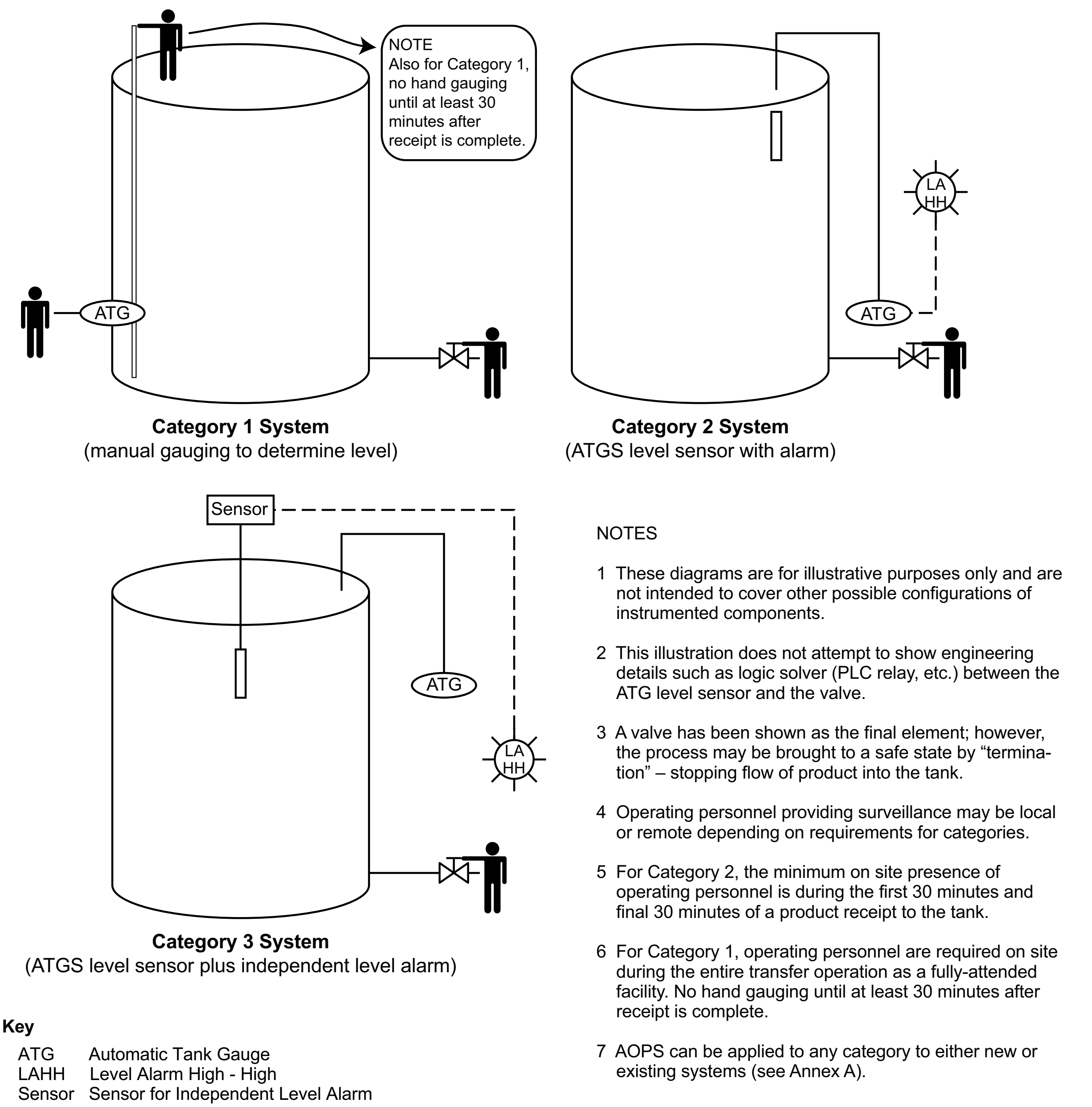


Figure 3—Illustration of Categories Applied to Overfill Prevention Systems

Note that side gauge on Category 1 can be ATG or Continuous level sensor and is optional

This standard applies to most of the commonly found equipment configurations for terminals taking receipts from marine or mainline pipelines and for tank-to-tank transfers. However, there are some configurations that are not covered by this standard although in service within the scope of API 2350. In these cases, the principles of this standard may be applied. Other tanks in service outside the scope of API 2350 are listed in 1.1.

4.4.5.2 Category 1 Facility

4.4.5.2.1 A Category 1 overfill prevention system may or may not have instrumentation. Even if it does have instrumentation, it is local to the tank or the facility and does not transmit liquid level or alarm data to the transporter. If shutdown or diversion is required to prevent an overfill, it should be done manually requiring personnel action by:

a) intervention at the local facility to terminate flow to the tank; or

b) by the transporter after receiving “manual” communications from personnel at the site.

4.4.5.2.2 Category 1 shall be operated as a fully-attended facility for receipts with monitoring continuously during first hour of receipt, every hour during the receipt, and continuously during the last hour of the receipt, as indicated in Table 2, since there are no remote monitoring capabilities by the transporter for either alarm or level information. Safety considerations prohibit hand gauging during product receipt or during the 30 minutes after completion (see API 2003).

4.4.5.2.3 Category 1 shall not be used where, because of the frequency of receipts or the complexity of the facility or terminal, the operator cannot reasonably be expected to focus fully on termination of one receipt at a time or may be distracted with other duties or responsibilities.

4.4.5.3 Category 2 Facility

4.4.5.3.1 A Category 2 overfill prevention system shall have an ATG system with level transmittable to a local control center or a remote control center. It uses the same sensor for level and high-high alarm (LAHH) both of which can be transmitted. Typically alarms are transmitted to a remote control center. This transmission of alarm data to a control room is a key difference between Category 1 and Category 2.

4.4.5.3.2 Category 2 systems may be operated as a semi-attended facility for receipts if the level alarms are monitored by a control center. At a minimum, personnel shall be at the facility with tanks at the start of a receipt and transfer operation (start denoted by the flow of product) and attend the operation for 30 minutes. In addition, personnel shall attend the last 30 minutes of the receipt and transfer operation (end denoted by the stop of product flow.) Personnel may also be required to be at the facility periodically during the receipt.

4.4.5.3.3 If operated as semi-attended, the transporter is required to assist with monitoring the receipts via the high-high tank level alarms and shall be in communication with personnel responsible for the receiving tank. The control centers shall have the ability to terminate (stop or divert) product flow to the facility.

4.4.5.4 Category 3 Facility

4.4.5.4.1 A Category 3 overfill prevention system uses both an ATG and an independent level alarm high-high sensor (LAHH). The key difference between Category 2 and Category 3 is that the LAHH sensor is independent of the ATG and alarm data is transmitted to a control center (with discretionary transmission of level data as determined by facility and shipper agreed protocols).

4.4.5.4.2 A Category 3 site may be unattended if both level data and alarms are monitored by the transporter.

4.4.5.4.3 The independent LAHH sensor (either a point level or continuous level device) may be connected to the common ATG or SCADA system only if the ATG or SCADA system is electrically supervised and provides diagnostic alarms to the transporter.

4.4.5.4.4 Tanks in fully automated operation at unattended facilities shall be equipped with an independent LAHH sensor that shall activate an alarm with the transporter to initiate termination procedures or shall automatically terminate the flow to the tank. These systems shall also initiate receipt termination procedures in the event of a power failure in the level measuring system based on an appropriate response time (4.4.2.5).

4.4.5.5 Additional Safeguards and AOPS

When a risk gap analysis shows that risk does not satisfy acceptance criteria, and risk reduction through process or procedural changes does not satisfy the criteria, additional risk reduction shall be provided as necessary to meet the acceptance criteria using independent safeguards, layers of protection and AOPS. An AOPS can be added as an additional level of protection to any category of facility; however, it is important not to impair the function of pipeline relief tanks by the addition of an AOPS.

4.5 Requirements for Overfill Protection Process (OPP) Procedures

4.5.1 General

Procedures shall be established for the following components of OPP:

— management system (4.5.2 and Annex B);

— risk assessment (4.5.3 and Annex E);

— operating procedures (4.5.4);

— training; and

— equipment system procedures.

4.5.2 Procedures for Management System

If procedures for a comprehensive OPP management system do not exist, then they shall be developed or shall be incorporated by reference into any suitable existing management system. The documented procedures for the management system shall address all components of OPP. These include typical administrative controls (i.e. management of change, operating personnel training and ability to audit the OPP components).

Annex B provides a high-level overview of a management system applied to overfill prevention. However, this standard does not provide details for development or deployment of a management system. It is the responsibility of the owner and operator to develop and apply these systems to OPP.

4.5.3 Procedures for Risk Assessment

Procedures for performing risk assessments on tank systems subject to overfills shall be developed and implemented for use in OPP. These may be either qualitative or quantitative. Annex E provides a conceptual overview.

4.5.4 Procedures for Operations

Documented operating and maintenance procedures for the overfill prevention system shall be established by the owner and operator and (where appropriate) coordinated with and agreed by the transporter. In accordance with the management of change component of OPP, the documented operating procedures shall be reviewed on a regular basis and revised or amended as the facility equipment or personnel change.

Procedures may use alerts as needed to specify non-OPP related or normal routine operating personnel duties and functions or for receipts controlled by automated basic process control systems. **Policies and procedures shall prohibit the use of high-high tank level alarms and AOPS for routine operation or control of tank filling operations.**

Because equipment, instrumentation, tanks, types of facility and transporter operations differ, one set of general operating procedures cannot apply to all facilities and may not even be applicable to all tanks or operations within a facility. Therefore, each owner and operator shall prepare documented operating procedures for specific locations, tanks, and local conditions that address OPP using the principles of this standard.

In the most basic conceptual form, procedures should require planning that determines the quantity of product to be received into a tank, the amount of space available in the tank, other simultaneous tank activities, the time required, whether a change in receiving tanks shall be needed (and when) and who shall be the action party monitoring the activity. Specific procedures vary depending upon the type of gauging and alarm equipment, the degree of automation and integration with the transporter.

As a minimum, the requirements in the following sections shall be included in the normal tank receipt and transfer procedures for all tank categories.

4.5.4.1 Procedures for Planning for the Receipt

4.5.4.1.1 Specific documented instructions for the receipt shall be prepared and reviewed (as appropriate) with personnel from all involved transporters and facility operators. These instructions shall include normal operational controls and procedures for tank receipts that fill tanks to the maximum working level. A higher level of readiness and control is needed when switching from one tank to another during the same receipt.

A higher level of readiness is also needed if:

a) a tank is to be filled above its maximum working level (though this standard does not recommend this practice);

b) multiple tanks are being filled simultaneously; or

c) a tank is receiving product from multiple sources.

4.5.4.1.2 Prior to receipt, the relevant documented procedures shall be identified and available, and product quantities to be received shall have been determined and compared to receiving tank available capacity to ensure that sufficient tank capacity shall be available. Planning shall be conducted sufficiently ahead of receipt to minimize the need for last minute product transfers or withdrawals from a designated receiving tank prior to receipt.

4.5.4.1.3 To provide for a safety margin with respect to overfill, the maximum working level of each tank should be used in calculating available capacity.

4.5.4.1.4 The anticipated final liquid product level in each tank shall be determined prior to each specific scheduled receipt and should not exceed the maximum working level.

4.5.4.1.5 Determine fill times by assigning responsibility for completing fill time calculations to: local operating personnel for Category 1 and Category 2 tanks; local or remote operating personnel (as appropriate) for Category 3 tanks.

4.5.4.1.6 The facility operator shall assign required duties to designated personnel before start of the receipt (or duties may be documented as normal duties of a particular designated job).

4.5.4.2 Procedures for Pre-Receipt Activities

4.5.4.2.1 Prior to product receipt, the tank(s) designated to receive product shall be gauged manually or by an independent automatic gauging and measuring system to confirm that adequate capacity is available to receive the amount of product scheduled for receipt. Any expected volume increase (e.g. product temperature rise in the tank(s), other receipts or activities) shall be considered when determining the available room for product.

The pre-receipt information shall be recorded on the tank product transfer or receipt record(s) and shall be available to the transporter.

4.5.4.2.2 Before the product is transferred or received, a proper valve line-up shall be verified to ensure that the product shall be delivered into the designated tank or tanks. Where piping is connected from the same receiving manifold to different tanks:

— only the inlet valves for those tanks designated to receive product should be open; and

— the inlet valves for all other tanks shall be closed.

4.5.4.2.3 Drain valves for dikes where receiving tanks are located (secondary containment) shall be kept closed during product receipt except when drawing water out of dikes with surveillance and should normally be kept closed.

4.5.4.2.4 Prior to starting product transfer to attended facilities, communications shall be established between the transporter and the facility operator, and maintained throughout the product transfer. Establish minimum communications frequency between facility operating personnel and transporter consistent with transporter's requirements. The lower the OPS level, the more frequent the communications should be. Therefore:

— for Category 1, the parties may communicate at least once at start of receipt, periodically during the receipt, and once within one hour prior to the end of receipt; but

— for Category 2 and Category 3, the parties are only required to communicate at the start and end of a receipt, additional communication is discretionary.

4.5.4.2.5 Prior to starting product transfer to unattended facilities, transporters shall ensure that electronic supervision is operating properly.

4.5.4.3 Procedures for Activities During Receipt

4.5.4.3.1 The documented operating procedures shall require regularly scheduled monitoring of product levels during receipts. Monitoring may be conducted on site or remotely (either manually or electronically) and shall include records of product movement

4.5.4.3.2 The documented operating procedures shall require that regularly scheduled comparisons and recording of the following information be made based on the tank capacity, the flow rate, and the estimated filling time:

a) the remaining available tank capacity shall be compared to the remaining volume of product to be received; and

b) the product level indicated on the instruments shall be compared to the expected level at any given time during the product transfer.

4.5.4.3.3 Tanks that are connected to the same product manifold, but that are not scheduled to receive product shall be monitored to ensure that there is no unintended flow.

4.5.4.3.4 During the product receipt, frequent acknowledged communication shall be maintained between the facility operator and the transporter to provide sufficient response time to shut down or divert product flow if necessary (4.4.2.5).

4.5.4.3.5 Immediately after the start of product delivery or transfer the tank(s) designated to receive product shall be checked by personnel responsible for facility operations ("person in charge" at marine facilities) to verify that product is flowing into the correct tank and that the gauging equipment (where installed) is operative.

4.5.4.3.6 During the product receipt, tanks shall be checked periodically by personnel responsible for facility operations in accordance with established facility procedures to ensure that the product continues to flow into the correct tank and that the tank capacity remains sufficient to receive the amount of product scheduled for delivery. Gauge readings in a manner not requiring personnel on top of a tank shall be taken and recorded when checking tanks during product receipt.

4.5.4.3.7 During the product receipt, the tank farm area shall be periodically inspected by personnel responsible for facility operations to ensure the integrity of the piping, tanks, pumps, dikes and other containment and drainage systems, and to ensure that no unauthorized activities are taking place that may affect product receipt.

NOTE This requirement does NOT apply to unattended Category 3 tanks.

4.5.4.3.8 Procedures shall be established that ensure continuity of communications and control between shift operations for shift changes while receipts are in progress. (See Table 2.)

Table 2—Monitoring Product During Receipt

Category 1 Facilities Shall be Attended	**Category 2 Facilities If Semi-Attended**	**Category 3 Facilities If Unattended**
	Emergency conditions (equipment malfunction or power failure) may require operation as a Category 1 facility (see 4.5.4.7).	
Attendance continuously during first hour of receipt.	Attendance continuously during the first 30 minutes of receipt.	No local monitoring requirements. For unattended facilities, continuous monitoring during receipt by the operator, transporter or by computer.
Every hour during receipt.	Hourly not applicable.	See above.
Attendance continuously during the last hour of receipt.	Attendance continuously during the last 30 minutes of receipt.	See above.

4.5.4.4 Procedures for Post Receipt Activities

At the conclusion of the receipt, the facility receiving system shall be secured. This includes closing tank inlet valves that were opened for product receipt (and where appropriate) closing the facility product receipt valve(s) or manifold valves, dock valves, and other safeguards appropriate for the facility.

4.5.4.5 Documentation for Product Receipt

All documentation of the above activities associated with the receipt of product from transporters shall be maintained on file in the facility for an appropriate period of time as determined by facility operator policy or as established by regulation or other authority. Documentation relating to inspection and maintenance of systems shall be maintained for a minimum of one year or longer as required by operator policy, regulation, or other authority and consistent with NFPA 30.

4.5.4.6 Filling a Tank Above its Maximum Working Level

This standard does not recommend the practice of filling a tank above the maximum working level. This increases the risk of overfill and should be avoided.

4.5.4.7 Procedures for Emergencies

Both the facility operator and transporter shall prepare and have available orderly, clearly documented procedures for handling various types of potential emergencies, including (but not limited to) the following:

a) action to be taken in the event of an alarm (ranging from product diversion or emergency shutdown to notifying emergency response personnel or deploying environmental barriers);

b) action to be taken in the event of an overfill and subsequent product release including potential vapor cloud formation with volatile products (i.e. gasoline); and

c) action to be taken in event that a component fails, loss of communication for levels or alarms or utility outages (i.e. used for verifying communications between operator and transporter).

Where applicable, the emergency procedures shall be developed by the facility owner and operator with the assistance of the transporter (as required) and documented and accessible.

As a minimum, the following emergency procedures shall be developed and documented as follows.

a) Facility owner, operators and transporters shall develop documented procedures and train personnel to provide for the proper course of action in the event that the overfill prevention system fails. In the event of abnormal conditions (i.e. operating, equipment, environmental, weather related), these procedures shall include assigning personnel to be in attendance at normally unattended facilities during product receipt from transporters.

b) Facility owner, operators and transporters shall develop documented procedures that provide for the proper course of action in the event that a mechanical or electrical power failure or diagnostic alarm indicates an affect on the sensor system in an unattended facility. These procedures shall be documented in accordance with the manual gauging operations required for attended Category 1 facilities without sensors that provides for using on-site personnel to gauge tanks (without placing personnel on top of the tank) during product transfer until such time that the sensor system is repaired and back in operation. If a mechanical gauging system is used as a back-up when electronic systems are not functioning, the fill-time calculations should be confirmed and the mechanical gauge shall be verified by a sufficient number of hand gaugings prior to receiving a delivery to ensure that the mechanical gauge is operational and reflects the proper tank level.

4.5.4.8 Personnel Performance and Training for OPS

4.5.4.8.1 Competent personnel are an important element of every tank overfill prevention process, regardless of the sophistication of the overfill protection system.

4.5.4.8.2 Provisions shall be made for training operating personnel in tank receipt and overfill prevention. Programs shall be developed by facility owner, operators and transporters to train personnel engaged in transfer operations, including those persons assigned to test, inspect, and maintain overfill prevention systems. Where relevant, the PHMSA (DOT) requirements for control room personnel should be satisfied.

4.5.4.8.3 These programs shall be reviewed (and updated as necessary) as operating procedures, equipment, instrumentation and regulatory requirements change. Personnel assigned to test, inspect, and maintain overfill prevention systems shall be competent in the specific procedures associated with such systems for which they are responsible.

a) Before personnel from owner, operators and transporters are assigned to participate in a product transfer or receipt, they shall be thoroughly familiar with the documented procedures and operating instructions, their duties, the operation of the overfill prevention system, the alarm and signal system, the emergency procedures and shall have received any mandatory training.

b) The training given to personnel shall be documented. This documentation shall include the type and content of the training programs and materials, the training date(s), the names of the persons trained, and the names of the instructors or supervisors.

c) To maintain competency, the performance of facility operator and transporter personnel shall be regularly monitored by supervisors or other appropriate personnel, and remedial or refresher training shall be provided as necessary, or when operating conditions, equipment, instrumentation or regulatory requirements change.

d) Owner and operators shall conduct periodic audits or reviews or inspections of product receipt operations to ensure that procedures are followed to prevent tank overfills.

4.5.5 Procedures for Testing, Inspection, and Maintenance of OPS

4.5.5.1 General

For manual or automatic overfill prevention systems to provide the designed protection intended, they should be tested, inspected and maintained.

4.5.5.2 General Requirements

Documented procedures shall be developed by the owner and operator for testing, inspecting, and maintaining an OPS. Where appropriate, the facility operator shall consult with the transporter regarding the development of these procedures:

a) the manufacturer's recommendations should be taken into consideration when developing procedures for testing, inspecting, and maintaining an OPS;

b) industry standards, government regulations, facility owner and operator policies, and special situations may necessitate additional inspection, testing, and maintenance procedures;

c) records of overfill prevention system testing, inspection, and maintenance shall be maintained for at least three years (or longer if required by facility operator policy or regulations); and

d) reviews should be conducted when changes occur in owner and operator and transporter practices, products, equipment, tanks and tank assignments, instrumentation, systems and conditions, or applicable regulatory requirements that may be subject to MOC review.

4.5.5.3 Testing OPS Equipment

All components of OPS system shall be tested and documented:

a) testing of hand gauges shall comply with requirements in API *MPMS* Ch. 3.1A;

b) testing of continuous-level sensors shall comply with requirements in API *MPMS* Ch. 3.1B;

NOTE Verify at least quarterly the continuous-level sensor reading. (As noted in API *MPMS* Ch. 3.1B, Section 9.2.2 "If operating experience confirms stable performance within the verification tolerance, the verification schedule can be extended to once a year".)

c) proof testing of AOPS components shall be conducted annually unless otherwise supported by a technical justification (i.e. a probability of failure on demand calculation);

d) proof testing of point- level sensor systems shall be conducted semi-annually unless otherwise supported by a technical justification (i.e. a probability of failure on demand calculation); and

e) proof testing shall be conducted at least annually of all other OPS components not listed above that are required to terminate the receipt including components (i.e. operator alerts and alarms).

4.5.5.3.1 Schedules shall be established for periodic testing, inspection, and maintenance to ensure the accuracy and proper operation of tank level gauges, sensor alarms and signals, floats, displacers, automatic shutdown systems, electronic supervision, and other equipment and instrumentation associated with product transfer:

a) an overfill prevention system shall be tested upon initial installation and retested frequently enough as required thereafter to determine its reliability and to develop data that establishes the testing, maintenance, and inspection schedules;

b) the facility owner and operator shall establish these schedules based on experience and performance; however, the inspection and testing interval shall not exceed one year unless justified by calculations determining probability of failure on demand;

c) specific recommendations of the relevant equipment manufacturer should be considered when establishing inspection and maintenance procedures and intervals;

d) some facilities choose to test newly installed systems on a more frequent basis during the first few months as they develop an experience database; and

e) facilities subject to PHMSA (DOT) regulations should review relevant regulatory test schedule requirements.

4.5.5.4 Proof Testing

4.5.5.4.1 Proof testing is an essential element for continuing reliability of overfill prevention systems. Preferably the testing procedures should be in a sequential (step by step) format to ensure safe, consistent practices, and the testing procedures should be accessible to personnel responsible for the testing, inspection, and maintenance of the system.

a) The proof testing requirements of this section are intended to apply to independent alarms and to all components and systems related to AOPS such that these requirements test as much as possible of the entire overfill prevention system including the sensor, the logic solver and the final element. The testing should simulate an actual high liquid level situation as realistically and as closely as possible; however, the test need not require filling the tank above its maximum working level. While the testing can be done on partial elements of the loop, the combined procedure shall ensure that all elements of the entire loop are tested within the proof testing interval even if different parts of the loop are tested at different times within that test interval.

b) A written testing procedure shall be developed by the operator that includes function testing of the sensor, the logic solver and the final element, the manufacturer's instructions, management of change from test mode to operation mode and vice versa.

c) A wet probe test uses the actual process liquid or water to trigger the sensor in situ that in turn provides the alarm or AOPS function. All components, logic solvers and final elements are thereby tested from sensor to output function (alarm or AOPS activation). However, for tanks in service with hazardous liquids, this kind of test may not be practical or it may not be deemed to be safe in its implementation. Technical justification shall be documented to show how the integrity of the sensor is maintained at an adequate level.

4.5.5.4.2 When new tank systems are fitted with sensors or tanks are out of service for inspections, cleaned and gas free, consideration shall be given to performing full wet probe tests either with water or with product. When product is used the operational and safety considerations shall be considered and addressed. When water is used, consideration shall be given to the ability of the sensors to detect water and to provide an appropriate test of the overfill prevention system. Consideration should also be given to the higher specific gravity of water.

4.5.5.4.3 When it is not possible or feasible to perform a wet probe test, then a test shall be designed by the owner and operator to simulate as much of a wet probe test as possible even if this requires testing different components at different times. This written testing procedure shall include function testing of all loop elements, manufacturer's instructions, management of change from test mode to operation mode and vice versa and the potential failure modes and effects of the device. Testing shall demonstrate that an AOPS functions as specified at the required trip level. The goal of this procedural development is to develop the best possible test that exercises as much of the instrumentation loop as possible, consistent with the considerations stated above.

4.5.5.4.4 In addition, the owner and operator shall consider and implement manufacturer and vendor recommendations and requirements for installation, maintenance and testing as well as any specific company or jurisdictional requirements.

4.5.5.5 Inspection of OPS Equipment Components

Simple inspection procedures specific to the system in use should be established in accordance with manufacturer's recommendations.

a) When the tank is in service, inspection should be done from the outside without entering the tank. Such inspections can provide visual evaluation of moisture intrusion, corrosion, and possibly operation of switches, cables and floats (where installed). It should be recognized that entry onto the roof of a floating roof tank may constitute confined space entry (see API 2026).

b) When the tank is out of service for internal work, the inspection of gauging equipment elements should be included in the project scope. Preferably, this inspection or testing should be done shortly before the tank is returned to service to ensure that gauge functionality was not compromised by other work.

4.5.5.6 Maintenance of OPS

Maintenance instructions should include diagnostic routines to permit prompt identification and repair of failures in accordance with manufacturers' recommendations. If there are false alarms, then the source of false alarms and signals shall be determined and corrected as quickly as possible. Frequent false alarms and signals lead to a loss in alarm credibility of the overfill prevention system and may result in a normalization of deviation from the established operating and emergency response procedures.

Where automatic gauging and measuring systems are used, regular inspection, maintenance, and checks of their capability and performance are required.

5 Requirements for Equipment Systems

5.1 General Requirements for Overfill Prevention Systems Equipment

5.1.1 General

Equipment systems are the physical systems with which the operating personnel interface to transfer product, including (but not limited to) tanks, piping, valves, sensors, instrumentation, gauges, electronic data collection systems, testing devices, and communication systems. All these system components (including cable, junction boxes) shall be suitable for the application and environment for which they are installed and installed in accordance with the component supplier's specification.

There are two types of equipment overfill prevention systems (OPS) generally used to terminate a receipt:

— MOPS: Manual overfill prevention system that depends on the interaction of operating personnel to terminate the receipt. A person physically turning a valve or pushing a button that remotely closes a valve or turns off a pump are both manual operations. In MOPS, the alerts and alarms provide the operating personnel with information only.

— AOPS: Automated overfill prevention systems (discussed in Annex A) that use instrumentation, sensors, logic solvers and final elements at the receiving terminal or tank which prevent an overfill by automatically terminating the receipt in accordance with 5.4. AOPS systems require no manual intervention.

Equipment related to OPS typically includes:

a) alarm signal system,

b) automated valves (i.e. pneumatic, electric, hydraulic) and manual valves,

c) communications equipment,

d) sensors (e.g. level, temperature, flow – see Annex C for commonly used liquid level sensors), and

e) logic solvers (e.g. relays, PLCs).

5.1.2 Alarms

Alarms signal a potential emergency and require specific response action.

5.1.2.1 Required LOC Alarms (except Category 1)

The high-high alarm (initial alarm at the high-high tank LOC) requires that operating personnel from the responsible owner and operator and transporter shall take previously defined and agreed action to terminate the receipt.

5.1.2.2 Diagnostic Alarms

When a diagnostic alarm is used to signal a system fault or other system malfunction, operations personnel shall act to implement "abnormal operating" procedures for the equipment that has potentially failed (see 4.5.3.7).

5.1.2.3 Optional Alarm (or notification)

Where a facility has chosen to use an alarm (or other notification) at the critical high level, the alarm shall be cause to activate emergency procedures and notifications.

5.1.3 Alerts

Alerts (also known as notifications) inform operating personnel (either at a facility or at a remote monitoring control center) that the tank liquid is at a defined (non-Alarm) level. Alerts are different from alarms in that they do not require specific action defined by this standard. Alerts may indicate need for investigation or owner and operator defined action.

Use of Alerts to provide information for operations personnel is acceptable, but not required by this standard.

Examples of optional information Alerts:

— critical high LOC,

— high tank LOC (as defined in previous versions of this standard),

— maximum working level, and

— minimum working level.

Any number of alerts can be set for a tank and do not need to be documented on OPP documentation for conformance with this standard (but should be documented for operations reference).

5.2 Alarm and Control Systems

The overfill prevention alarm systems (when installed) shall be located so that the assigned facility owner and operator operations personnel and transporter operations personnel are notified to take action in accordance with agreed procedures when a sensor signals that the liquid level in a tank has reached an established level of concern (see Figure 1 and Figure 2).

Different types of control and alarm systems may be used to monitor field sensors. These systems typically provide control or activation of remote final control devices (i.e. closing valves, stopping pumps or initiating diversion), but also share the alarm system functionality. Control panel selection depends on facility operator and transporter policies and practices, and the various functions desired.

Alarm annunciators, computer display systems, human machine interfaces (HMI), SCADA and alarm and signal control panels shall include appropriate visible and audible alarms with test features (where appropriate), power backup, and communications to remote locations (where required).

Control system options include:

a) alarm and signal indicator lights whereby colors may be selected in accordance with facility operator or transporter practices or local requirements;

b) audible and visible alarm display with silence and acknowledge features;

c) alarm (annunciator) systems and control panel push button provided with lights (Incandescent or LED) shall be provided with the ability to “test” the light without initiation of the alarm or push button;

d) ability to activate visible display signals and audible alarms to alert personnel at locations remote from the control panel location;

e) ability to activate or control automated valves associated with automatic shutdown or diversion;

f) ability to signal to or communicate with remote locations (i.e. pipeline control centers, facility operator remote offices, marine dock, security services);

g) capability to “reset” and indication of when reset is required;

h) capability to initiate a manual termination; and

i) an alarm and signal to indicate a power failure to the alarm and signal control system (including field devices) and an alternate power source for backup.

5.3 Alarm Signals

In some facilities, the main control panel (or control center) is located in an area that is not continuously staffed, or in continuous communication (e.g. radio) with field operating personnel. In these situations, the control panel alarm and signals, devices to alarm and signal high-high (if used), and notify, alert or alarm critical high tank level conditions shall be located in other facility areas where they shall be monitored. Potential alternate sites are a storage tank area, marine dock, pipeline manifold, receipt operation control centers and transporter control location where the alarm devices can be readily seen and heard. Personnel in those areas are responsible for initiating corrective action to prevent an overfill. Facilities where personnel are not on site full time during receipts shall ensure that the alarm and signals are activated at locations where personnel can respond and initiate action to prevent an overfill incident or utilize an AOPS.

Selection of audible and visual alarm and signal equipment (i.e. horns or lights) shall comply with the electrical classification of the area in which they are installed (see API 500).

The high-high tank level alarm signals shall be distinctive from all “alerts”.

A visual and audible alarm shall be activated in the event that the high-high tank LOC is reached and is recommended for critical high notification, alert or alarm (if used). Audible and visual trouble alarm shall be activated on detection of fault or failures within the alarm system to include its associated power supply system. Each of the above conditions should initiate a trouble alarm with predetermined actions.

5.4 Automated Overfill Prevention System (AOPS)

In this standard, when an AOPS is required (by the risk analysis, owner and operator policy or regulation), it shall be applied according to the following options:

— option 1 – for existing facilities: an AOPS as described in Annex A provides an acceptable approach for achieving and demonstrating adequate integrity; and

— option 2 – for new facilities: an AOPS designed and managed in accordance with requirements of ANSI/ISA 84.00.01-2004 (IEC 61511 modified) “Functional Safety: Safety Instrumented Systems for the Process Industry Sector” shall be required.

5.5 Automated Valves in OPS

When automated shutdown or diversion systems are provided, the receiving valve (or valves) for each facility or tank shall be equipped with an automated actuator that has provisions for both local and remote automated closure. Valve actuators may be electrically, hydraulically, pneumatically or mechanically operated and shall be designed to permit local manual operation in the event of loss of motive power. Loss of valve operator motive power shall initiate an alarm and shall trigger specific procedures to terminate or divert receipt or shall result in final elements automatically going to their safe state.

When the AOPS system receives notification that the product in the tank has reached the AOPS level the system shall:

a) change appropriate valve(s) to the safe open (closed) state(s) at the agreed-upon valve travel speed(s); if the valve is being opened (closed) remotely when the AOPS sensor signal is received, the valve shall immediately start moving to the safe state at the predetermined rate;

b) inhibit movement of the valve(s) from the safe position until the system has been reset from the local alarm and signal control panel, the site has become attended, and operating procedures for abnormal conditions have been implemented;

c) in case of power failure procedures shall be in place to promptly terminate receipt under manual control; and

d) the AOPS valves shall not be operated manually unless specific procedures are used which require manual operation of the valve to address reducing the high liquid level.

The valve closure (opening) rate on tank receipt or transfer lines shall be determined to achieve termination of flow within the intended response time while preventing excessive hydraulic pressure transients or hydraulic shock. This may require analysis of facility piping system to determine whether a relief system shall be needed to protect low pressure manifold piping from overpressure. Design and operation of the AOPS shutdown system should be by mutual agreement between the tank facility owner, operator and the transporter.

Where actuator vents are restricted to limit the valve actuator and control speed of closure, a fixed orifice shall be used rather than a variable orifice (i.e. a needle valve). The fixed orifice size shall be documented on the valve instrument specification sheet along with the required speed of closure for the valve.

Valve position should be monitored to allow indication of valve operation. Position indicators shall indicate valve positions and valve operation. Limit switches should be provided to indicate the safe state position of the automated valve. The limit switch(s) should be used to notify control room operating personnel that the valve is in its commanded state and alarm when the valve is not in the state commanded (e.g. the valve has been commanded to go to the closed state, but the limit switches do not indicate “closed” based on valve position).

When a hand-controlled switch to provide local off, remote, or open control is used, the off (typically closed or safe position) and open (typically normal operating condition) positions of the switch shall be monitored with alarms on the alarm and control panel. This feature ensures that the switch is not inadvertently left in the open position.

5.6 Use of Uninterruptible Power Supplies (UPS)

In general, it is recommended that as a minimum the monitoring and control systems used in OPS are on a UPS system. However, sources of energy needed to operate valves or pumps associated with these systems do not need to be on UPS, but should be designed to move to a safe state in the case of a power loss event.

Annex A
(normative)

Automated Overfill Prevention Systems (AOPS)

A.1 Automated Overfill Prevention Systems (AOPS) for Existing Systems

Annex A provides good design, operation and maintenance practices for the implementation of an automated overfill prevention system (AOPS) for existing tank systems. AOPS based on the following guidance shall be reviewed by a competent person with a good knowledge of safety instrumented system design and management to ensure that all requirements of Annex A, as well as the relevant requirements in the main body of the standard are implemented properly.

A.2 Design

The design of an AOPS shall be implemented by a competent person knowledgeable in the design and management practices associated with safety instrumented systems and tank facility operations.

A.3 Independence

The AOPS shall be designed and installed so that failures associated with any other overfill prevention system (OPS) or ATG hardware, software, communications, wiring connections or cabling cannot cause a failure of the AOPS.

Correct operation of the AOPS shall not require communications to or from any location remote from the facility where the AOPS has been installed. AOPS shall not rely on wireless communication to initiate diversion or termination of receipt.

The term “independent” means that the AOPS shall be separate from any device or method used to measure, calculate or monitor tank receipts. The independent AOPS shall be designed and installed such that no fault in the ATG gauging and monitoring system is capable of causing a fault in the AOPS.

A.4 Equipment

A.4.1 Power

The AOPS shall be designed to terminate flow to the protected tank in the event of loss of power.

A.4.1.1 Uninterruptible Power Supply

When an uninterruptible power supply (UPS) is used, it should be sized to allow the AOPS to continue to function until the flow can be terminated, the flow can be diverted away from the tank or operations personnel can implement abnormal operating procedures to terminate or divert receipt. The UPS should be monitored so that when the UPS fails, an alarm is provided to operations personnel.

A.4.2 Sensors

Input sensors shall be connected directly to the AOPS logic solver.

The AOPS sensor shall be installed in a manner to minimize common cause failure between any other OPS (or ATG) and the AOPS.

Sensors with self testing diagnostic features are preferred for all AOPS tank level detection applications.

A.4.3 Logic Solver

The logic solver technology may be electrical (e.g. trip amplifiers) or programmable electronic (e.g. PLCs).

Where programmable electronic systems (e.g. PLC) are used as the logic solver, the relevant considerations are as follows:

1. The unsafe failure modes for the AOPS PLC shall be understood and addressed with safety configuration. The main failure modes that should be considered are (1) I/O points being stuck on or stuck off and (2) the process program stalling.

a) Detection of input and output (I/O) failures requires frequent diagnostic cycling of the I/O point and confirmation of correct action and detection by the PLC.

b) Detection of process program stalling requires an external watchdog timer (WDT). In many cases, a watchdog timer consists of a time delay relay that is installed external to the PLC. The PLC sends a reset to this watchdog timer frequently enough to prevent the timer from timing out. The watchdog "timing out" is an indication that the PLC has failed and the state of the tank being monitored by the PLC is unknown.

c) Users shall analyze and specify the actions required when PLC failure is detected. Some actions to be considered if a PLC failure is indicated by the I/O failure detection or WDT:

- send an alarm to monitoring locations (local and remote); this alarm should be generated by the WDT and not the PLC it monitors;
- automatically or manually terminate flow to or divert the flow of product from any tanks that have a LAHH monitored by the failed PLC; and
- activate AOPS; where possible PLC's shall be programmed to detect and alarm cabling faults, blown fuses and open circuits.

2. The PLC programming shall be restricted to the use of predefined library functions (i.e. ladder diagram, function block diagram, and sequential function charts).

3. The logic solver shall be protected against unauthorized or unintended modifications.

4. Any changes to the AOPS logic solver hardware or firmware shall be implemented in accordance with the instructions of the manufacturer and shall be subject to management of change procedures.

NOTE Additional information can be found in IEC 61511.

A.4.4 Final Elements

1. Separation and independence between the AOPS valve and the normal OPS control valve shall generally be required. Use of the OPS (or ATG) control valve as an AOPS valve is acceptable only when failure of the OPS (or ATG) control valve cannot cause overfill.

2. Valves shall be designed to fail to the safe state on loss of motive force (i.e. electricity, air or hydraulic pressure), unless technical justification for alternative design is provided and alternative means to divert or terminate the receipt are specified.

A.4.5 Documentation

The following documentation shall be maintained and approved by an authorized representative of the owner and operator:

1. piping and instrumentation diagrams that clearly show the 'as is' state of all AOPS equipment;

2. functional descriptions (i.e. logic narratives or loop diagrams) that clearly describe the AOPS functional requirements;

3. proof test procedures detailing how the AOPS is tested, what equipment is used, and what records are retained;

4. preventive maintenance plan showing planned inspection and maintenance to ensure ongoing integrity of the AOPS;

5. management of change procedure detailing how changes to the facility affecting overfill risk shall be reviewed and approved;

6. override and bypass management procedure detailing how the use of overrides and bypasses shall be reviewed and approved;

7. AOPS maintenance records related to proof testing, maintenance history, change history and a history of all equipment failures and action implemented to correct those failures; and

8. where PLCs are used, a record of software modifications and changes.

A.4.6 Installation and Commissioning

1. All equipment and cabling shall be installed in accordance with design documentation. Any changes in the AOPS design and installation shall be reviewed and approved through management of change and design documentation shall be updated to show the 'as installed' status.

2. All equipment and cabling shall be protected against likely physical damage.

3. All equipment and cabling shall be clearly tagged to allow identification and association with design and maintenance documentation.

4. All equipment and cabling shall be installed per manufacturer's instructions.

5. Installed AOPS shall be proof tested after initial installation, after any significant change and subsequently at specified intervals according to documented procedures and all equipment and cabling shall be visually inspected and discrepancies corrected.

6. All new AOPS equipment shall be proof tested as a complete functional entity (sensor through logic solver to final element) following installation and prior to start-up and introduction of hydrocarbons.

A.4.7 Testing

Proof testing shall be carried out according to approved documented procedures at defined test intervals as described in Section 4.5.4.2.

A.4.8 Operations and Maintenance

1. All operations and maintenance shall be carried out according to defined and documented procedures. Operating personnel and maintenance personnel shall be trained to ensure that they are competent.

2. Overrides shall be reviewed and approved according to a documented procedure as noted above in the documentation section.

3. Any override and bypass shall be removed as soon as practical. Where override and bypasses are in place for longer than one shift an MOC process shall be invoked and an alternate means of protection defined until the override and bypass can be removed and the equipment placed back in service.

Annex B
(informative)

Management Systems

B.1 General

Use of a management system focused on overfill prevention (the overfill prevention process) provides an efficient and systematic approach to effectively implement the intent of API 2350. In this standard, this process is called the overfill prevention process (OPP) and includes concepts of damage prevention resulting from unintended high product levels. The necessary elements for such a system may be integrated into the overall facility or organization management systems.

An effective overall management system is essential in order to implement the intent of API 2350 that is to minimize or eliminate the risk of tank overfills and damage. The necessary elements should be integrated into the facility or organization management systems. Resources for developing management systems include among others ANSI Z-10 *Occupational Health and Safety Management Systems* (OHSMS) (ANSI 2005), *ISO Integrated Use of Management Systems Standards* (ISO 2008) and *BS OHSAS 18001:2007* (BSI 2007).

B.2 Inclusion of Tank Overfill in Management System

The owner and operator's management system shall address the management of the risk of tank overfills. A comprehensive system that systematically addresses all aspects of the tank lifecycle can eliminate or minimize the occurrence of overfill events. This applies to people, processes and equipment relevant to filling operations and in particular to overfill prevention systems. The management systems should address the following aspects:

Owner and operators shall use a management system that includes addressing overfill prevention. A comprehensive system systematically addressing all aspects of the tank lifecycle shall minimize or eliminate overfills. Some management processes are built on the classic Shewhart "Plan – Do – Check – Act" cycle shown in Figure B.1. A tank overfill prevention management system built on this model can be integrated into an organization's overall management system by using specific overfill prevention element which apply to people, processes and equipment relevant to overfill prevention systems (OPS). A typical management process as shown in Figure B.1 includes:

— Planning: Defining policy and responsibilities to ensure the management process includes a comprehensive overfill assessment including safety, health and environment aspects. Elements of the planning process include hazard identification, risk assessment and defining risk control measures. Planning incorporates relevant regulations, codes and industry standards, documentation, design and construction, operating and maintenance procedures, training and emergency preparedness. While this standard sets out technical risk control measures, the accompanying management and procedural measures are part of the overall overfill prevention process.

— Doing: Implementing and integrating risk control measures in the day-to-day operation of the facility that includes structuring to provide competence of engineering, operations and maintenance personnel as part of the implementation of the operations and risk control plan.

— Checking: Monitor, review and audit plan implementation as part of facility performance; including effectiveness of tank overfill prevention management controls. Evaluate whether the defined risk control measures (both technical and procedural) are in place and properly maintained and working in practice. The checking phase includes functional testing, inspection, auditing and non-conformance investigation.

— Acting: Acting on findings from the "Check" phase to mitigate identified tank overfill risks associated with facility operations and feeding this information back into the management planning cycle. The "act" phase includes correction of identified deviations, management of change and eventually decommissioning.

— Planning: Planning repeats to make any adjustments needed as start of a new cycle in the management process.

At any stage in the management process cycle related processes relevant to overfill prevention may be identified as within the scope of the management system in use. These should be integrated into the cyclic management process and may prompt initiation of a new Planning phase.

NOTE This standard does not specify how to implement a management system. That task is the responsibility of the owner and operator.

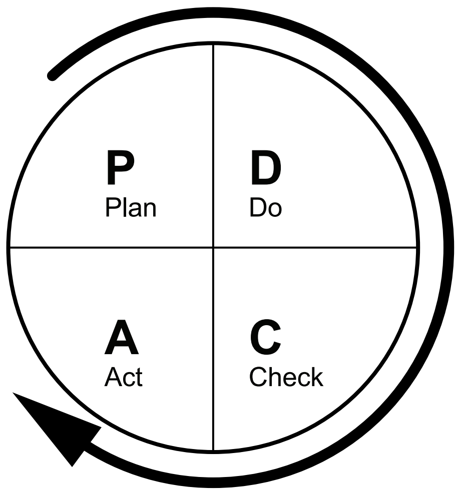


Figure B.1—The Management System Cycle

Annex C
(informative)

Liquid Level Instrumentation Considerations

The types of sensors available are:

1. Point Level Sensor

a) this type of sensor can be used for a high-high tank level alarm for Category 1 and Category 2 tanks;

b) independent point level sensors can be used as a high-high tank level alarm for Category 3 and AOPS tanks; and

c) there are point level sensors which may offer self-diagnostic and system analysis for proof testing options.

2. Continuous Level Sensor

a) this type of sensor continuously measures the level of the product in the tank;

b) continuous level sensors can be used to measure both level and provide a high-high tank level alarm in Category 2 and Category 3 tanks;

c) continuous level sensors can be used as an Independent high-high level alarm for Category 3 and AOPS tanks; and

d) there are mechanical and electronic continuous level sensors:

  i) mechanical continuous level sensors can be used in Category 1 tanks where the ullage of the tank is calculated by the operator; and

  ii) electronic continuous level sensors can be used in Category 1 and Category 2 tanks when the ullage of the tank is calculated by the operator using a strapping table.

NOTE Some sensors offer self-diagnostic and system analysis for proof testing.

3. Automatic Tank Gauge (ATG)

a) high accuracy continuous level sensor that meets the specifications for API *MPMS* Ch. 3.1B recommendations;

b) suitable for use in Category 1, Category 2, Category 3 and AOPS tanks;

c) automatically calculates the tank ullage and innage for the operator to determine the tank capacity for a receipt;

d) ATG can be used as an Independent high-high tank level alarm in conjunction with another ATG in Category 3 and AOPS tanks; and

e) additional features:

  i) water measurement,

  ii) temperature measurement,

  iii) volume correction,

iv) high and low level relays for alerts, and

v) some ATG's offer self-diagnostic and system testing options that can be used for proof testing.

NOTE High-high tank level sensors used as part of the OPS on floating roof type tanks that measure the roof position instead of the product level should also be able to detect the presence or level of product on top of the roof in the event the roof sticks or sinks into the liquid.

Table C.1 represents the more commonly used types of liquid level sensors.

Table C.1—Commonly Used Types of Liquid Level Sensors

Type	Description
Float point mechanical sensors	Used to determine product level in cone roof tanks. As a tank is filled, the product rises within the tank lifting the float until a predetermined fill level is reached. The float then activates the alarm and signal using either a mechanical relay or reed switch.
Displacement electronic point sensors	Sometimes used in lieu of float sensors to determine product level or roof position in tanks where product may be agitated, surging, foaming or have low specific gravity.
Opto-electronic point sensors	Used to determine product level in all types of clear liquids. Opto-electronic level sensors use an infrared light source that passes through a light conductor that is refracted at a different rate when surrounded by air or liquid. When the liquid covers the tip of the sensor, there is a change in the refraction rate which activates the alarm and signal.
Weight (slack cable) mechanical point sensors	Mechanical level sensors are used to determine product level in a floating roof tank. As the tank is filled, the floating roof rises to a predetermined fill level where it contacts the weight. As the weight is lifted by the roof, the cable goes slack and the level switch opens, activating the alarm and signal. Electronic capacitance switches with a flexible cable can also be use to determine the position of the floating roof.
Tuning fork electronic point sensor	Vibrating fork level switches utilize a piezoelectric-driven tuning fork that exhibits a large change in resonant frequency when immersed into a liquid process changes from dry to wet or wet to dry.
Ultrasonic point sensors or Gap switches	Work on the principle that the signal strength from a sending piezo-crystal is less in air than in liquid.
Capacitance point and continuous electronic sensors	Uses the change in dielectric constant to determine the presence of the liquid for a high switch or the rise of the level for continuous measurement.
Radar (non-contact) point level and continuous sensors	Use a microwave signal that is reflected off of the liquid. FMCW or pulse time of flight is used to measure the time it takes for the signal to be returned to the sensor that is then converted into the distance traveled.
Radar (TDR or GWR) continuous sensors	Sends a microwave signal down a cable or rod, measures the time for the signal to return to the sensor and calculates the distance to determine the level. Can use rigid or flexible probes.
Servo continuous electronic sensors	Uses a displacer with neutral buoyancy supported on a wire that is connected to a resolver that measures the distance from the top of the tank to the top of the liquid.
Mechanical float and tape continuous sensors (electronic option)	Use a neutral buoyancy float to measure the distance from the top of the tank to the top of the liquid. This system uses a gear driven indicator to show the tank level and does not require power. An electronic option is available.
Magnetostrictive continuous sensors	Measures the position of the permanent magnet located in a float on a magnetostrictive wave guide. Can use rigid or flexible probes.
NOTE These are examples and are not intended to be inclusive of all possible technologies	

Annex D
(informative)

Determining Tank Capacity and LOCs

D.1 General

D.1.1 The capacity of a tank depends on the tank's type, size, configuration, condition and on the specified design liquid tank product levels. Tank capacity for internal and external (covered and open-top) floating roof tanks also depends on the type of floating roof, roof seal, roof cover, internal tank construction and appurtenances.

D.1.2 Each tank covered by this standard should have a current, up-to-date tank strapping chart (tank record) that depicts the actual conditions in the tank. The key values entered on the chart (or tank record) shall be calculated and established by the facility operator (see Figure D.1 and Figure D.2). These values include the following for each tank receiving product in the facilities covered by this document:

a) maximum working level (MW),

b) high-high level (HH), and

c) critical high level (CH).

D.1.2.1 Facility operators shall indicate the maximum working level, high-high level, critical high level, and any other critical capacities and levels on the record card, computer record and calibration chart, and make this information available to transporters.

D.1.2.2 The critical high level (lowest of overfill level or damage level discussed in Section 4.4.1.1) should be verified by an inspection of the tank. The critical high level should correspond to the last entry on the tank chart or record.

D.1.2.3 Tank capacity levels should be reflective of the floating roof and internal appurtenances.

D.1.2.4 If acceptable calibration charts are not available, tanks shall be calibrated in accordance with API *MPMS* Ch. 2, *Tank Calibration* (all sections) and charts developed.

D.1.3 Management of change practices shall be applied and levels and detector settings adjusted whenever a tank is modified so as to affect its capacity. This includes (but is not limited to) mechanical changes (i.e. providing a double bottom, adding an internal floating roof, changing construction of the floating roof or placing a cover over an open top tank) as well as operational changes (i.e. a change in receiving flow rates or product type). See Section 4.4.3.1 and Section 4.4.3.2.

D.1.4 Tanks used as pipeline relief tanks shall maintain the proper amount of free volume in the tank based on the anticipated relief event. This required volume should be adjusted for in the tank level either between HH and CH, MW and HH or in some other way as defined by the owner and operator.

D.1.5 Consult with the tank manufacturer if there is any question about tank capacity.

D.1.6 Figure D.1 shows a typical tank sensor level and fill level worksheet. Figure D.2 shows a typical tank high level critical worksheet and record.

Facility ______________________________

Tank no. ______________________________

Location ______________________________

Prepared by ___________________________

Date _________________________________

I. Receipt Information

1.	Maximum fill rate	barrels per minute	A
2.	Maximum response time for facility operator or transporter to begin to start shutdown or diversion	minutes	B
3.	Maximum time to achieve total shutdown or diversion after facility operator or transporter begins response	minutes	C
4.	Response time D = B + C	minutes	D
NOTE Item 1 to Item 4 shall be calculated for all simultaneous incoming sources.			
5.	Volume received during time period E = sum of A x D for each simultaneous line flowing to tank	barrels	E
6.	Volume (E) adjusted by safety factor F = E x (factor) safety factor (includes max measurement error) to be determined by facility operator	barrels	F
NOTE B and C may be different durations in response to maximum working as compared to high-high.			

II. Sensor and Fill Level Settings

1. Critical high level (CH)
   (Details: Section 4.4.2.1)

   CH = ______________________ (barrels)

   CH = __________ft __________ in.

2. High-high tank level (HH)
   (Details: Section 4.4.2.2)

   HH = (CH) - (F) ________________ (barrels)

   HH = __________ ft __________ in.

3. Maximum working level (MW)
   (Details: Section 4.4.2.3)

   MW = (HH) - (F) ________________ (barrels)

   MW = __________ ft __________ in.

Figure D.1—Tank Sensor Level and Fill Level Worksheet

Facility________________________________

Tank no. ________________________________

Location ________________________________

Prepared by ____________________________

Date __________________________________

Tank Height (TH) = ____________ ft ___________ in.

Liquid Level (L) = ____________ ft ___________ in.

Other Allowances (A) = ____________ ft ___________ in.

Roof thickness (calculated) (FR) = ____________ ft ___________ in.

Critical High (calculated) (CH) = ____________ ft ___________ in.

(CH) =TH – FR - A = TH (_______) – RT (______) – A (______) = ______ft______in.

(A = 0 if no internal appurtenances)

(FR = 0 if not a floating roof tank)

NOTE (TH) and (L) shall be measured from the same place (both from tank bottom or striker plate).

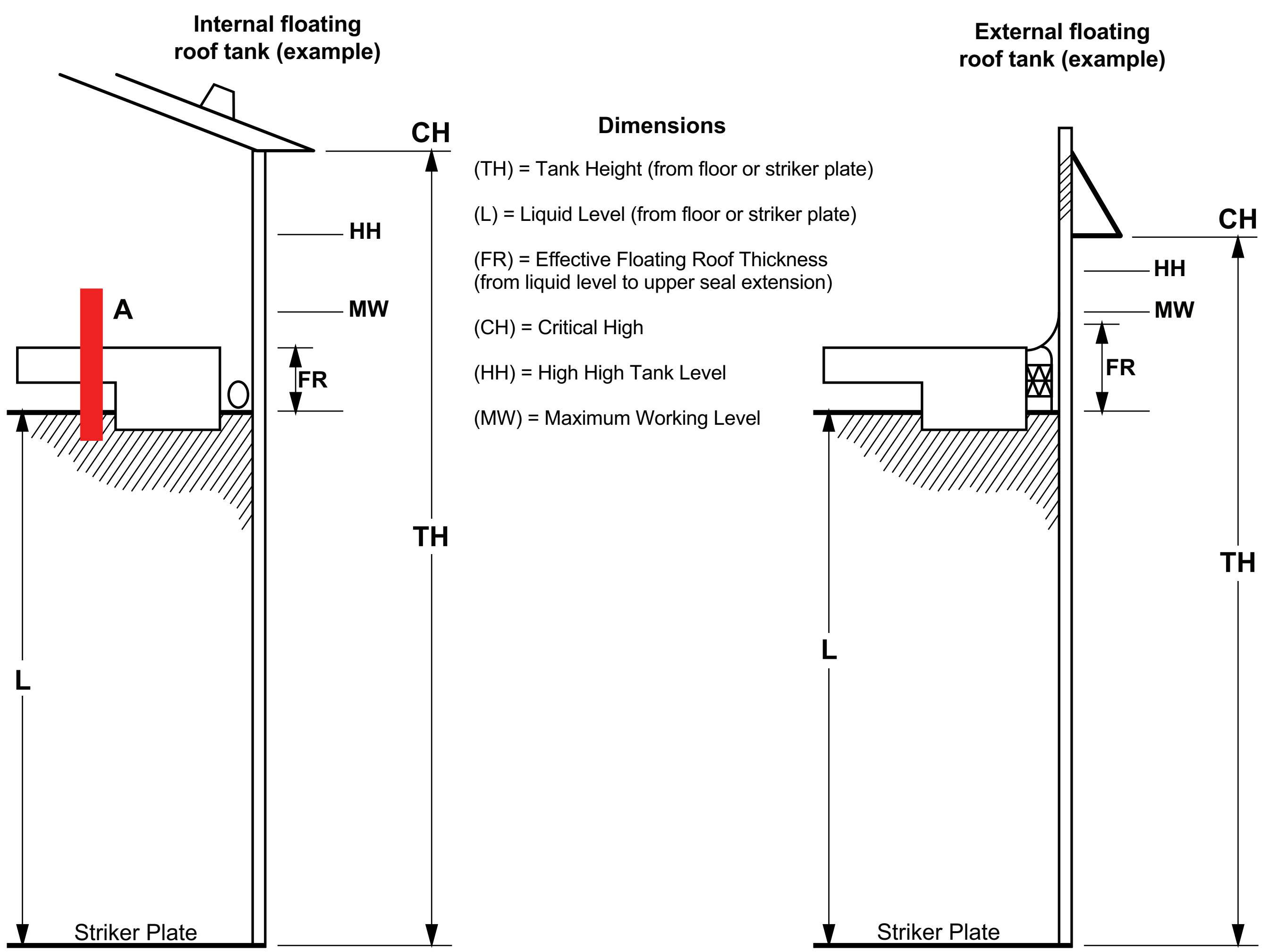


Figure D.2—Tank Critical High Level Work Sheet and Record

Annex E
(informative)

Conceptual Tank Overfill Risk Evaluation

A conceptual approach to evaluating the risks associated with potential tank overfills is shown in Figure E.1. As a "process" it involves periodic review of risks associated with tank operations which could lead to product overflow or tank damage. This process is consistent with the facility's management of change (MOC) process. Some factors to consider are described after Figure E.1.

A tank overfill risk assessment should consider factors that can influence the likelihood and consequence of a tank overfill and therefore the associated risk of overflow or damage.

Probability or Likelihood:

a) frequency, rate and duration of filling;

b) systems used to properly measure and size receipts to tanks;

c) accurate tank calibration (both strapping and verified critical high);

d) systems used to monitor receipts;

e) extent of monitoring and supervision of manual and automatic tank gauging;

f) impact of complexity and operating environment on the ability of operating personnel to execute overfill prevention tasks;

g) filling multiple tanks simultaneously;

h) switching tanks during receipt; and

i) a review of methods to quantify the probability of tank overfills can be found in API 353, A.2.4.

Consequence – Impact of Hazardous Material Release on Vulnerable Exposures:

a) hazard characteristics of material (product) in tank;

b) volatility, flammability, dispersion, VCE potential;

c) number of people onsite who may be affected by a tank overflowing;

d) number of people offsite who may be affected by a tank overflowing;

e) possibility of a tank overflowing resulting in (escalation) of hazardous events onsite or offsite;

f) possibility of impact to nearby sensitive environmental receptors;

g) physical and chemical properties of product released during overflowing; and

h) maximum potential overfill flow rates and duration.

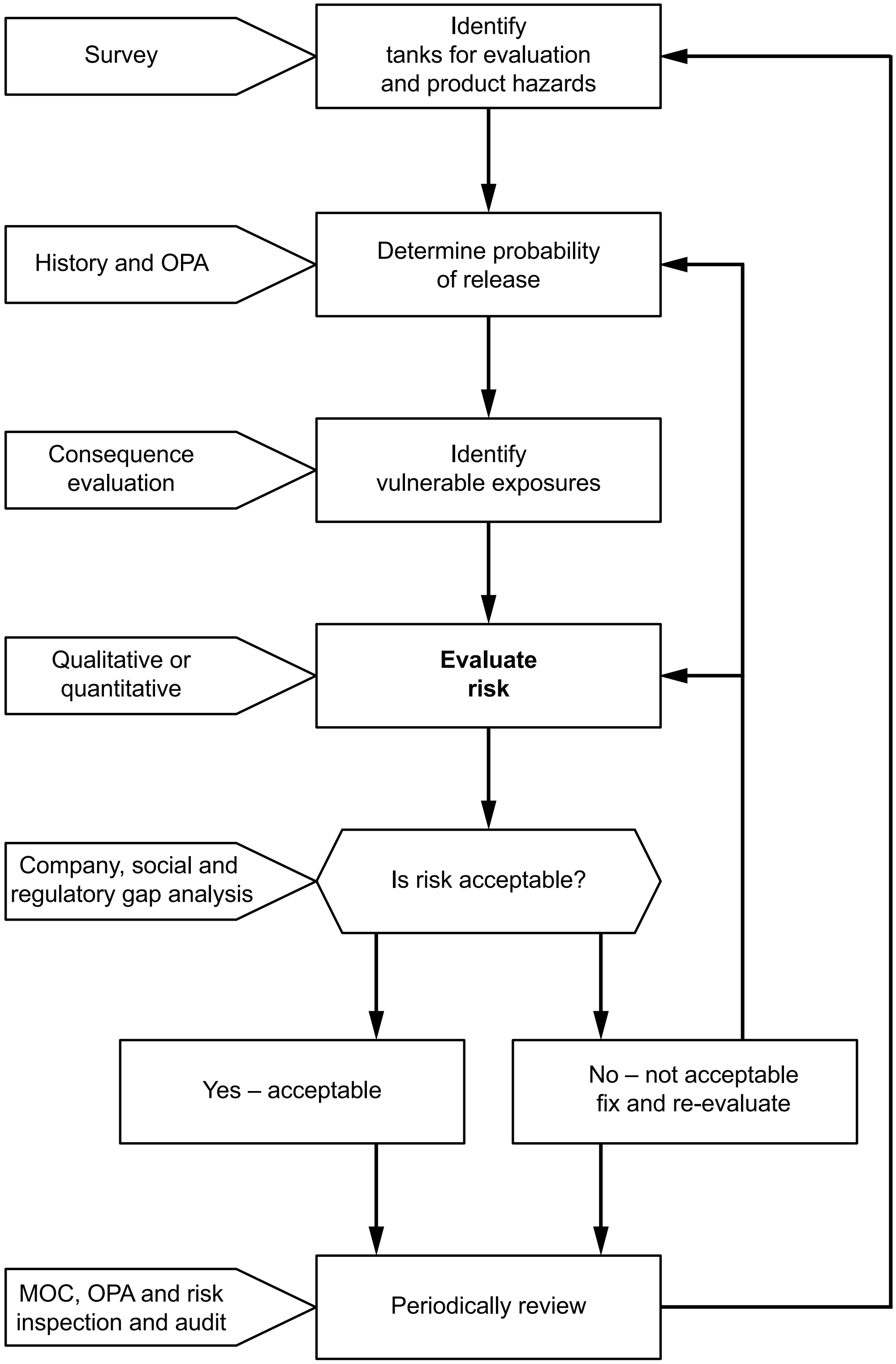


Figure E.1—Conceptual Tank Overfill Risk Assessment Process

Stakeholder factors to be considered:

a) individual and societal risk tolerance criteria (corporate and regulatory);

b) regulatory requirements; and

c) consideration of other risk reduction costs and benefits associated with non-tank facility operations.

When evaluating risk a "gap analysis" (comparison of risk assessment results versus expectations) can help determine whether a risk meets postulated "acceptable" levels. For a system already in service, this provides an opportunity to compare actual performance with its desired or potential performance. The process involves determining, documenting and approving any variance between current capabilities and requirements.

The most frequently used qualitative risk evaluation procedure is the probability-impact risk rating matrix sometimes in conjunction with "what-if" or checklist evaluations. A semi-quantitative approach is used in some regions (e.g. see Safety and environmental standards for fuel storage sites, Appendix 2 "Guidance on the application of layer of protection analysis (LOPA) to the overflow of an atmospheric storage tanks" Process Safety Leadership Group, published by the Health and Safety Executive (UK)) while some organizations use more formal quantitative approaches (i.e, fault tree or event tree analysis). IEC/ISO 31010:2010 Risk Management, Risk Assessment Techniques provides an overview and guidance in techniques that can be used to assess and evaluate the risks of tank overfills leading to product overflowing or tank damage. API Publication 353 "Managing Systems Integrity of Terminal and Tank Facilities – Managing the Risk of Liquid Petroleum Releases" provides a broad comprehensive review of risk management applied to tanks.

Bibliography

[1] API Manual of Petroleum Measurement Standards (American Petroleum Institute) 2.2A, *Measurement and Calibration of Upright Cylindrical Tanks by the Manual Tank Strapping Method*

[2] API Manual of Petroleum Measurement Standards (American Petroleum Institute) 2.2B, *Calibration of Upright Cylindrical Tanks Using the Optical Reference Line Method*

[3] API Manual of Petroleum Measurement Standards (American Petroleum Institute) 3.1A, *Manual of Petroleum Measurement Standards – Chapter 3: Tank Gauging, Section 1a – Standard Practice for the Manual Gauging of Petroleum and Petroleum Products*

[4] API Publication 353, *Managing Systems Integrity of Terminal and Tank Facilities – Managing the Risk of Liquid Petroleum Releases*

[5] API Publication 2026, *Safe Access/Egress Involving Floating Roofs of Storage Tanks in Petroleum Service*

[6] API Recommended Practice 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities*

[7] API Recommended Practice 1165, *Recommended Practice for Pipeline SCADA Displays (January 2007)*

[8] API Recommended Practice 1168, *Pipeline Control Room Management 09/00/2008*

NOTE API 1165 and 1168 are incorporated by reference in Paragraph 195.3.

[9] API Recommended Practice 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*

[10] API Recommended Practice 2009, *Safe Welding, Cutting, and Hot Work Practices in the Petroleum and Petrochemical Industries*

[11] API Recommended Practice 2021, *Management of Atmospheric Storage Tank Fires*

[12] API Recommended Practice 2201, *Safe Hot Tapping Practices in the Petroleum and Petrochemical Industries*

[13] API Standard 2545, *Method of Gauging Petroleum and Petroleum Products*

[14] API Standard 2610, *Design, Construction, Operation, Maintenance and Inspection of Terminal and Tank Facilities*

[15] AIChE[1] Center for Chemical Process Safety (CCPS), *Guidelines for Hazard Evaluation Procedures, 3rd Edition*

[16] AIChE Center for Chemical Process Safety (CCPS), *Layer of Protection Analysis*

[17] AIChE Center for Chemical Process Safety (CCPS), *Simplified Process Risk Assessment*

1 American Institute of Chemical Engineers, Center for Chemical Process Safety, 3 Park Avenue, 19th Floor, New York, New York 10016, www.aiche.org/ccps.

[18] American Industrial Hygiene Association[2], ANSI/AIHA Z-10, *Occupational Health and Safety Management Systems (OHSMS)*

[19] American Society of Safety Engineers[3], ANSI/ASSE Z690.1-2011, *Vocabulary for Risk Management (identical national adoption of ISO Guide 73:2009)*

[20] American Society of Safety Engineers, ANSI/ASSE Z690.2-2011, *Risk Management – Principles and Guidelines (identical national adoption of ISO 31000:2009)*

[21] American Society of Safety Engineers, ANSI/ASSE Z690.3-2011, *Risk Assessment Techniques (identical national adoption of ISO 31010:2009)*

[22] BSI Group[4], BS OHSAS 18001:2007 (BSI 2007), *Occupational Health and Safety Management Systems – Requirements*

[23] International Electrotechnical Commission (IEC)[5], *IEC 61511 Functional Safety: Safety Instrumented Systems for the Process Industry Sector*

[24] International Society of Automation (ISA)[6], ANSI/ISA 84.00.01-2004 (IEC 61511 modified), *Functional Safety: Safety Instrumented Systems for the Process Industry Sector*

[25] International Society of Automation (ISA), ANSI/ISA S84.01 – 1996 – ISA TECH 1999, *The Treatment of Existing Systems,* Angela E. Summers, Kimberly A. Dejmek

[26] International Standards Organization[7], IEC/ISO 31010:2010, *Risk Management, Risk Assessment Techniques*

[27] International Standards Organization, *The Integrated Use of Management System Standards – 2008*

[28] McGraw-Hill[8], *Dictionary of scientific and technical terms (4th ed.). Parker, S. P. (Ed.). (1989)*

[29] McGraw-Hill, ISBN: 007044272X, *Aboveground Storage Tanks by Phillip E. Myers*

[30] McGraw-Hill, *OGP Risk Assessment Data Directory Report No. 434 – 15 March 2010 (free download – http://www.ogp.org.uk/pubs/434-15.pdf)*

[31] McGraw-Hill, *Systems Psychology. De Greene, K. B (Ed.) (1970)*

[32] National Fire Protection Association (NFPA)[9], NFPA 30, *Flammable and Combustible Liquids Code 2008*

[33] Petroleum Equipment Institute (PEI)[10], Recommended Practice 600, *Recommended Practices for Overfill Prevention for Shop-Fabricated Aboveground Tanks - 2007*

2 American Industrial Hygiene Association, 2700 Prosperity Ave., Suite 250, Fairfax, Virginia 22031, (Tel.) 703-849-8888, (Fax) 703-207-3561, www.aiha.org.
3 American Society of Safety Engineers, 1800 East Oakton Street, Des Plaines, Illinois 60018, www.asse.org.
4 BSI Group, 389 Chiswick High Road, London, W4 4AL, United Kingdom, www.bsigroup.com/en/.
5 International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH-1211, Geneva 20, Switzerland, www.iec.ch.
6 The Instrumentation, Systems, and Automation Society, 67 Alexander Drive, Research Triangle Park, North Carolina, 22709, www.isa.org.
7 International Organization for Standardization, 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, www.iso.org.
8 The McGraw-Hill Companies, P.O. Box 182604, Columbus, OH 43272, www.mcgraw-hill.com.
9 National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02169-7471, www.nfpa.org.
10 Petroleum Equipment Institute, P.O. Box 2380, Tulsa, Oklahoma 74101-2380. www.pei.org.

[34] UK Process Safety Leadership Group and UK HSE, *Safety and environmental standards for fuel storage sites - Appendix 2 Guidance on the application of layer of protection analysis (LOPA) to the overflow of an atmospheric storage tank* – Process Safety Leadership Group, published by the Health and Safety Executive (UK) 2009, ISBN 978 0 7176 6386 6

[35] U.S. Coast Guard, Department of Homeland Security[11], 33 CFR PART 154, *Subpart D – Facility Operations for Facilities Transferring Oil or Hazardous Material in Bulk*

[36] U.S. Environmental Protection Agency[12], 40 CFR 112, *Spill Prevention Control and Countermeasure (SPCC) Rule Regional EPA Inspection SPCC Plan Guidance Manual Nov. 28, 2005 – www.epa.gov/OEM/docs/oil/spcc/guidance/SPCC_Guidance_fulltext.pdf*

[37] U.S. Harry G. Armstrong Aerospace Medical Research Laboratory Wright Patterson AFB, Dayton, OH: Crew System Ergonomics Information Analysis Center (CSERIAC), *CSERIAC-89-01 Human Factors, Ergonomics, and Human Factors Engineering: An Analysis of Definitions,* Deborah M. Licht and Donald J. Polzella, Kenneth R. Boff

[38] U.S. OSHA[13], CFR 29 1910.119, *Process Safety Management of Highly Hazardous Chemicals*

[11] U.S. Coast Guard Marine Safety Center (part of DOT), 2100 Second Street, S.W., Washington, DC 20593, www.uscg.mil.
[12] U.S. Environmental Protection Agency, Ariel Rios Building, 1200 Pennsylvania Avenue, N.W., Washington, DC 20460, www.epa.gov.
[13] U.S. Department of Labor, Occupational Safety and Health Administration, 200 Constitution Ave., NW, Washington, DC 20210, www.osha.gov.

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